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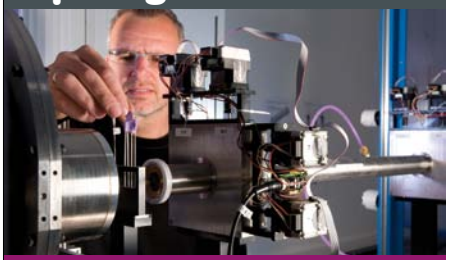

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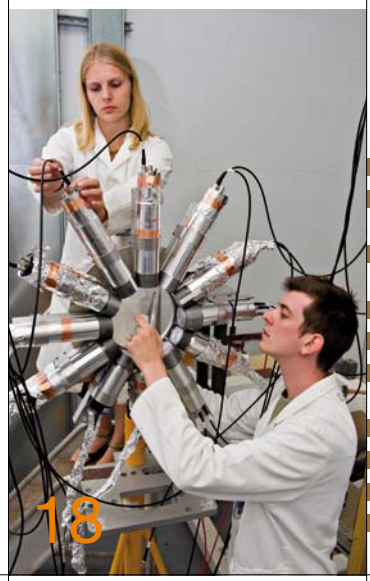

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Special release
25th March 2011

At the time of going to press, after-shocks are continuing in the wake of the most severe earthquake in Japanese history, which occurred off the coast of Sendai on 11th March 2011. The North-Eastern shores of Japan were devastated by the tsunami triggered by the earthquake. The reactor cooling systems and spent fuel storage pools at the Fukushima nuclear power plant were unable to resist.

More than two weeks later, the accident is still ongoing. We do not yet know whether our Japanese colleagues will manage to control it and prevent the serious dispersal of radioactivity into the environment or human irradiation above authorised limits. At this stage, it is hard for CEA to express an opinion on this major accident. Our sincerest hope is that no more victims will be added to the already terrible toll caused by the earthquake and the tsunami.

"IN FRANCE, THE POPULATION, THE NUCLEAR STAKEHOLDERS, THE EXPERTS AND THE STAFF AT CEA ARE AS ONE IN THEIR SOLIDARITY AND ADMIRATION OF THE JAPANESE PEOPLE"

In France, the population, the nuclear stakeholders, the experts and the staff at CEA are as one in their solidarity and admiration of the Japanese people, who are facing this disaster with such courage and dignity. As soon as news of the events was received, the President of the Republic of France sent a message of solidarity and offered the Japanese authorities technical help and manpower, in particular in the field of radiation protection and nuclear safety, which therefore involved CEA. Fire-fighters, along with specialists in nuclear, radiological, biological and chemical risks were immediately sent out. For many years, Japan has been a close partner of France. Many French engineers and researchers are working there on long-term assignments, while we at the same time welcome Japanese scientists. This understanding of the Japanese nuclear situation gives our French experts a full role to play within the assistance organisation set up with British, American and Russian specialists.

In the aftermath of the disaster, it will be essential for the decision-makers, researchers, industry and the public at large to analyse the feedback from this major nuclear accident. That will take time. In the upcoming issues of CEA News, together with our experts, we will attempt to understand the accident and identify possible reactions and responses in terms of safety and energy policy in general.

The Editor

The International Year of Chemistry is up and running!

The international year of chemistry was officially launched by the UN on January 27th and 28th, at the Unesco headquarters in Paris. Among those attending these events was: Bernard Bigot, CEA Chairman.

Under the banner "Chemistry – our life, our future", this international year aims to promote awareness and understanding by the general public of how chemistry can address mankind's global needs. It also aims to attract young people into this field.

CEA has made a major commitment to the event and proposes celebrating this discipline through its key areas of research: batteries, fuel cycle and design of new medication.

Bernard Bigot will present CEA's programs at the "Chemistry for the nuclear energy of the future" Symposium, on 5th April 2011 at the Palais des Congrès in Montpellier. This event will mark the International Year of Chemistry and the centenary of the Nobel Prize awarded to Marie Skodowska-Curie.

AREVA
La chimie pour le nucléaire du futur
vous donne rendez-vous à Montpellier !
Colloque le 5 avril 2011
au Palais des congrès « Le Corum » - Montpellier - France
Chimie
pour l'énergie nucléaire du futur
Invitée d'honneur
la Pologne
www.nuclearchemistry2011.com

Tara Oceans
A strong hand at the helm

As the Tara Oceans expedition begins its second year, which will take it from the Cape to Auckland, via Buenos Aires, Ushuaia, Clipperton or Papeete, the 15 partners in this unique research project have signed a global agreement on the governance of the consortium.
This document has the merit of clearly identifying the rights and duties of all parties. It recalls that Tara Oceans is founded on one inviolable principle: release to the entire international community and the public of all the data collected during this expedition, the goal of which is to study biodiversity and the relationship between the climate and the oceans.
The Genoscope is closely involved in this adventure, as it is responsible for sequencing all the samples taken from all the world's oceans.

http://oceans.taraexpeditions.org/

Very large research instruments and infrastructures
Strengthening scientific and industrial collaboration

From research ship to satellite, from telescope to LHC collider at the CERN, very large research instruments and infrastructures play a vital role in fundamental research in a large number of disciplines. The field of high-energy physics, which explores both the infinitely small and the infinitely large, is one of the most demanding in terms of instrumentation.

Design studies, first prototypes and fine-tuning of these precise technological choices right up to the actual construction of the instruments themselves is a process that may well consist of thousands of subassemblies and sensors, and requiring extreme accuracy in environments that can be both hostile and highly technical, such as in an ultra-vacuum at just a few degrees Kelvin, in space, in deserts or even 2,500 m below the surface of the sea.

On December 21st 2010, the CNRS, CEA and **SOLEIL** signed a scientific and industrial collaboration agreement with the **PIGES** Association.

This agreement has two primary objectives:
- Enhance the partnership between academic research and companies and increase the number of joint R&D projects on the large research instruments, in particular in nuclear and high-energy physics, using very large radiation centers such as synchrotrons.
- Strengthen exchanges between industry and laboratories, to improve understanding of the needs, tools and services of each (technological obstacles to be overcome, respective roadmaps and corresponding technological choices to be made).

This type of scientific cooperation already exists in the United States, Asia and other European countries. In close liaison with the very large research instruments and infrastructures Committee at the CNRS, the aim is for this specific collaboration between academic research and industry in France to be extended to other organizations and industrial partners, thus helping to strengthen Europe's position on the international competitive stage.

SOLEIL
is a very large research infrastructure, created on October 2001 by the CNRS and CEA with the support of the Île-de-France Region, the General Council of the Essonne and the Centre Region. SOLEIL is both a source and a laboratory for use of French synchrotron light and is one of the world's most powerful synchrotrons for exploring matter, its fundamental mechanisms, its structures and its evolution, in disciplines such as physics, biology, chemistry and so on.

PIGES
Industrial partners in the large scientific instruments. The aim of this association, founded in April 2010 by a group of 11 industrial companies, is to meet the technology requirements of the national and international research organizations concerned by the very large research instruments and infrastructures. The founder companies and members of the PIGES Association Board are: Air Liquide/Altal, Antecim, Alcen, SDMS Technologies, Bodycote, Sigmaphi, Brucker, Sominex, Mecachrome, Onet Technologies/ Comex Nucleaire, Thales.

High-performance computing: opening the door to the future

On October 25th 2010, the Minister for Higher Education and Research, Valérie Pécresse, inaugurated CEA's Very Large Computing Center (TGCC) building. This exceptional infrastructure of 6,500 m² is located on the CEA DAM-Ile-de-France site, near Paris and is designed to house the large supercomputers that are today an essential tool in research and innovation. They open the door to unprecedented levels of simulation and modeling of the most complex phenomena.

The TGCC was selected to house the future European petaflop computer acquired by Genci (large national intensive computing equipment) under the European Prace partnership (Partnership for Advanced Computing in Europe). This supercomputer, which will be operational in late 2011, will be capable of executing more than a quintillion of operations per second.

CEA, with its partners Intel, Genci and the University of Versailles Saint-Quentin-en-Yvelines, has also inaugurated the Exascale Computing Research center (ECR). The objective is to begin preparing for the next generation of supercomputers, which will be able to work on the "exascale", or carry out one septillion of operations per second. CEA is contributing its computer architecture, simulation software, modeling and programming tools expertise. Energy, seismology, fluid dynamics and health are among the sectors selected for this collaboration.

EC Innovation Director visits **CEA Grenoble**

On September 21st 2010, Georgette Lalis, the Director of Industrial Innovation and Mobility Industries at the European Commission's Directorate General for Enterprise and Industry, along with Costas Andropoulos, head of the ICT for Competitiveness and Innovation Unit, were at CEA Grenoble.

On this occasion, Georgette Lalis visited the site and its various research infrastructures dedicated to key generic technologies identified by the European Union (nanotechnologies, micro and nano-electronics, advanced materials, photonics, biotechnologies).

This visit was part of the new European initiative addressing these technologies and in which CEA is a participant. The high-level group on key enabling technologies is chaired by Jean Therme, the Director of CEA Grenoble, CEA Director of Technology Research and Deputy Director for renewable energies reporting to the Chairman.

After the Brussels launch on July 13th, a first report was submitted to the European Commission in January with the final recommendations report scheduled for July 2011.

The visit by Mrs Lalis and Mr Andropoulos positions the Grenoble innovation ecosystem and model, for which CEA Grenoble is the technological cornerstone, at the heart of the European Union's approach to the development of these key technologies of the future.

EERA launches three new joint **research programs**

On November 15th and 16th 2010, in Brussels, the European Energy Research Alliance (EERA) officially launched three new joint energy research programs: CO_2 capture and storage, New materials for the nuclear industry and Bioenergies. Following the launch of the first four joint research programs in June of last year, EERA is continuing to enhance collaboration by the Member States of the European Union for research in the field of energy technologies.

Since EERA was created in 2008, it has aimed to strengthen, expand and optimize European research capacity in the energy sector, through joint pan-European research programs, as set out in the European Strategic Energy Technology Plan (**SET Plan**), for the period 2013-2020.

The seven programs launched will involve more than 1,000 researchers from nearly 70 public research institutes throughout Europe. Almost €100 million will be invested by the organizations involved.

SET Plan
The European Strategic Energy Technology Plan was launched by the European Commission in 2007 to boost the cost-effective development and implementation of low-carbon technologies.

ABOUT EERA

EERA is currently run by 15 organizations heavily involved in energy research: "Austrian Institute of Technology", AIT (Austria), "Alternative Energies and Atomic Energy Commission", CEA (France), "Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas" CIEMAT (Spain), "Centre for Renewable Resources", CRES (Greece), "Energy Research Centre of the Netherlands", ECN (Netherlands), "Italian National Agency for New Technologies, Energy and Sustainable Economic Development", ENEA (Italy), "Helmholtz Association", HZ (Germany), "Institute of Power Engineering", IEN (Poland), "Laboratorio Nacional de Energia e Geologia", LNEG (Portugal), "Paul Scherrer Institute", PSI (Switzerland), "National Laboratory for Sustainable Energy", RISø-DTU (Denmark), "Foundation for Scientific and Industrial Research", SINTEF (Norway), "UK Energy Research Centre", UKERC (UK) and "Technical Research Centre of Finland", VTT (Finland).

Unprecedented **cooperation**

Unprecedented scientific cooperation was launched in Europe in October 2010 by CEA's **Leti** institute and the German **Fraunhofer-IISB institute**. This cooperation is dedicated to efficient management of renewable energies and, initially, to the development of photovoltaic panels. It will be built around scientific exchanges. The aim will be to encourage the joint definition of new research projects. A young German mechatronics engineer will thus be the first to benefit from this agreement. His PhD will be financed by the two institutes, and he will split his time between the two, while preparing his thesis.

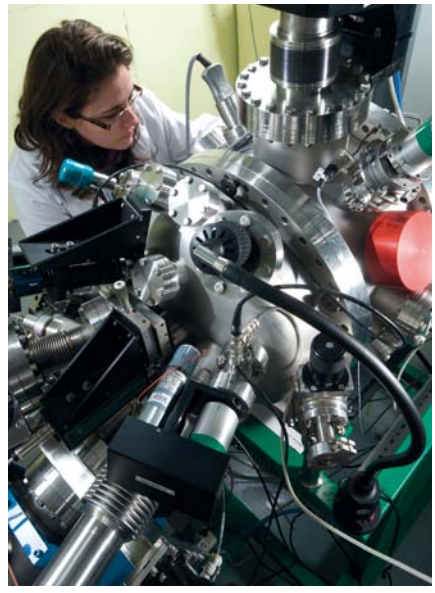
Other exchanges should take place to develop innovative electronic concepts, in particular in the field of photovoltaic power. The goal is to improve the flexibility, efficiency, reliability and robustness of the systems.

Leti
The Electronics and Information Technologies Laboratory is one of Europe's main centers of applied research in electronics for industry.

Fraunhofer-IISB institute
Fraunhofer-institut fur Integrierte Systeme und Bauelementetechnologie.

Jannus welcomes participants in **IAEA's SMoRE research project**

The mid-term meeting for IAEA's coordinated research project entitled "Accelerator Simulation and Theoretical Modeling of Radiation Effects", or SMoRE, was held in 2010, followed by a visit to the **Jannus** installation on the Saclay site. It brought together about twenty participants from fifteen countries: Belgium, China, France, India, Japan, Kazakhstan, Netherlands, Poland, Russia, Slovakia, South Korea, Spain, Switzerland, Ukraine and the United States. During their visit to the Jannus multi-beam irradiation platform, the participants were able to see for themselves that these two installations are now operational. A number of partners expressed interest in submitting requests for beam time on Jannus.The three-year SmoRE project is contributing to the development, testing and improvement of the structural materials used in water-cooled or fast-neutron nuclear reactors.



One of the objectives of Jannus is to experimentally simulate the ageing of nuclear reactor materials, using a bombardment of heavy and light ions. Another is to observe and understand damage to and intentional modification of materials at nanometer levels.

Jannus
Acronym for Joint Accelerators for Nano-science and Nuclear Simulation, is a multi-beam irradiation platform.

Strengthened scientific cooperation between **France and Sweden**

On December 13th 2010, in Stockholm, CEA, CNRS and **UVSQ** signed five cooperation agreements with various Swedish research institutes (**VR, ESS AB, SKC/KTH**) in the fields of neutron physics, climate sciences and nuclear energy of the future. **GANIL** and the University of Uppsala also signed a declaration of intent. These agreements, to last from six to seven years, strengthen scientific cooperation between the two countries, in parallel with French support for the future European Spallation Source (ESS) project.

The ESS will be the world's most powerful neutron source. The high intensity of the neutron beams, obtained by spallation, and the development of new observation methods will enable scientists to analyze and understand physical phenomena at the atomic and molecular levels. Construction of the ESS should shortly begin in Lund, with the facility being commissioned at the end of the decade.

Two agreements and the declaration of intent directly concern neutron physics:
- Between CEA, the CNRS and the ESS AB company, for joint studies on the design and testing of components for linear accelerators;
- Between the Léon Brillouin Laboratory and the Swedish research council, for neutron physics instrumentation methods;
- Between GANIL and the University of Uppsala, for setting up scientific exchanges and research projects on their respective installations.

The other three agreements concern climate sciences and research into nuclear energy of the future:
- Between the Climate and Environmental Sciences Laboratory (CEA-CNRS-UVSQ) and the Swedish research council, for research leading to responses to calls for proposals in the field of climate sciences, and to work on setting up the European ICOS (Integrated Carbon Observation System) network to measure greenhouse gas flows;
- Between CEA and SKC for training of Swedish students on CEA's ISIS neutron model in Saclay;
- Between CEA and the Swedish research council, for a Swedish contribution to the R&D program associated with the ASTRID 4th generation prototype reactor project, and the experiments conducted on the future Jules Horowitz research reactor (under construction at CEA's Cadarache facility).

UVSQ
Université Versailles-Saint-Quentin.

VR
Swedish research council (VR, Vetenskapsrädet).

ESS AB
ESS AB is the company that is to design, build and operate the future European Spallation Source, in Lund.

SKC/KTH
Swedish nuclear technology centre (SKC, Svenskt Kärntekniskt Centrum), part of the Stockholm Royal Technical School (KTH, Kungliga Tekniska högskolan).

GANIL
Large national heavy ion accelerator, an economic interest group comprising CEA and the CNRS.

Polish partnership anniversary

One year after cooperative agreements between CEA and its Polish partners were signed, deputy Chairman Hervé Bernard and a delegation visited the Polish team, which was the opportunity to highlight all the work being done and the prospects for cooperation.

Hervé Bernard recalled the success of the two phases of the Polish instructors training program set up by the AFNI (France International Nuclear Agency) at the end of 2009 and 2010 and the importance of the transfer of the computer codes, a key element if Poland is to acquire its own expertise in dealing with safety issues.

ENVIRONMENT

Evaluation of **environmental research**

The **CEA Visiting Committee** met from October 25th to 27th 2010 in Bruyères-le-Châtel and Saclay at the invitation of the High Commissioner for Atomic Energy, Catherine Cesarsky, to evaluate the topic "Earth System and anthropic activities: CEA environmental research".

It examined the following three areas:
- research on the natural environment,
- research to understand the climate system and the effects of human activities on the evolution of the climate,
- research on the potential environmental effects of technological activities in CEA' fields of research.

The Visiting Committee stressed the importance that will be attached to environmental issues in the energy choices of tomorrow. CEA's assets include its Environmental Assessment and Monitoring Department, with its long experience of setting up and operating international environmental surveillance networks. The Climate and Environmental Sciences Laboratory conducts cutting-edge research programs in the climate sciences and offers cross-disciplinary expertise on all aspects concerning the risks relating to technological activities, particularly in the nuclear field.

The Visiting Committee underlined the broad spectrum and the quality of this research, which gives CEA the ability to anticipate and shed light on the future choices that will need to be made in terms of energy mix and the corresponding technologies.

The CEA Visiting Committee
comprises external scientific personalities. The experts present were Rodney Ewing - Chairman of the committee -, Guy Brasseur, Gou-Chung Chi, Serge Haroche, Emile Okal, Ernst Detlef Schulze, Eric Wolff, Genki Yagawa and Dan Yakir. The opinions of the Visiting Committee are communicated to the CEA governing bodies and to its supervisory ministries.

Cancun

The 200 countries present in Cancun on November 11th 2010 adopted a text of measures designed to combat climate change and to set up a Green Fund to help developing countries. This agreement should also encourage the protection of tropical forests and promote clean technologies such as solar and wind.

IPCC

8 researchers from the Climate and Environmental Sciences Laboratory, including 4 from CEA, will be among the 258 experts from around the world selected to draft the "global warming" part of the 5th edition of the report by the IPCC, the Intergovernmental Panel on Climate Change, scheduled for 2013.

THE FUTURE OF SEPARATIVE CHEMISTRY: WELCOME TO THE ICSM

Chemical separation is a key step and a factor in the efficiency of a large number of industrial processes. It can, for example, be used to carry out extremely advanced "sorting", at an atomic and molecular level, for recycling of elements considered to be reusable and for isolating – and thereby minimizing – elements of no value (waste). Mastering the finer points of separation also makes it possible to develop highly innovative chemical substances, capable of being used in hostile environments.

Delphine Nicolas - Press feature - June 2009
Web site http://icsm.fr

/ THE INSTITUTE AIMS TO BECOME A BENCHMARK

The purpose of the Institute of Separative Chemistry, a combined CEA-CNRS-UM2-ENSCM research unit, is the nanometer level study of interfaces in extreme conditions, designed so that we can understand the mechanisms governing separation phenomena that occur in nuclear complex fluids and materials, against a backdrop of sustainable development.

The Institute aims to become a benchmark, firstly at a European level, and then globally.

The aim of sustainable nuclear power

In close liaison with the technological research activities of the CEA centre in Marcoule, near Avignon, the Institute's priority mission is to develop innovative processes and materials for the fuel cycle of tomorrow's nuclear reactors.

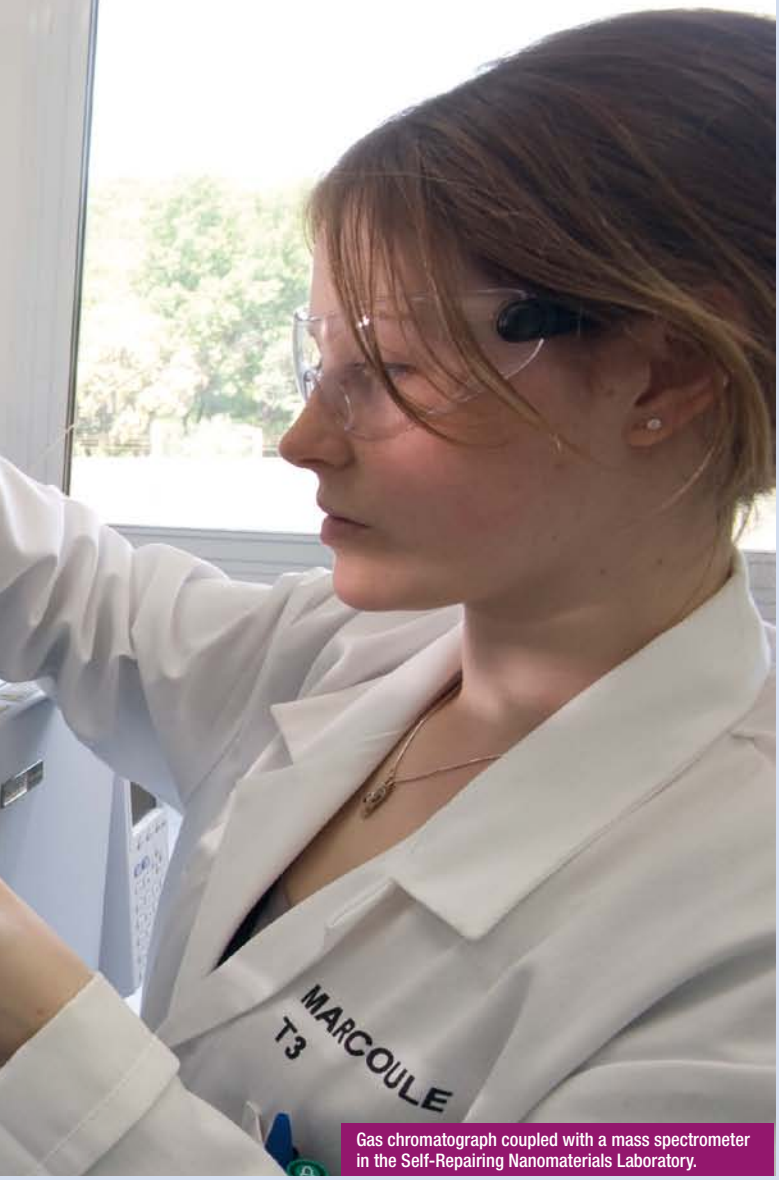
These "4th generation" reactors will be entering service in about 2040, and are expected to produce fifty to a hundred times more electricity than current reactors, while consuming 50 to 70% **natural uranium**, as opposed to today's reactors that consume 1%, because they only produce energy from the fission of nuclei of uranium 235, the only fissile isotope of natural uranium. The future reactors should be able to "burn-up" by fission not only the 235 isotope of uranium, but also uranium 238 by converting it into plutonium 239, which is also fissile. Uranium 238 could thus be consumed in the reactor to generate electricity. This technology would multiply by a factor of 100 the availability of global primary fissile resources. Initially, it would also use the uranium 238 obtained from reprocessing of current spent fuel and depleted uranium, an enrichment by-product made up 99.7% of uranium 238.

Use of the "4th generation" reactors will also, through transmutation of the minor actinides, shorten to a few centuries the time after which the radio-toxicity of the waste returns to a level comparable with that of the initial uranium ore.

Achieving these goals implies taking a completely new look at the fuels for these reactors, whether in terms of their composition or their recycling (when they are "spent" and removed from the reactor). Among the dozens of chemical species present in the spent fuel, this in particular means being able to sort out those that could be recycled in a reactor, either because they are reusable or because they are highly toxic. This sorting is done using specific molecules and is known as separative chemistry.

Enhancing Marcoule's fundamental research potential

The Institute of Separative Chemistry is enhancing Marcoule's fundamental research potential in the study of the basic phenomena involved (for example in the selective separation of radioactive elements), in various media of interest (aqueous and organic solutions, molten salts and metals, **supercritical fluids**), at various scales of observation: from the molecular scale to that of macroscopic complexity. Theoretical work and experimentation will be carried out in parallel



Gas chromatograph coupled with a mass spectrometer in the Self-Repairing Nanomaterials Laboratory.

at the Institute's laboratories and in **Atalante**, on extremely diverse element concentrations (from nano-concentrations up to highly concentrated media).

The Institute's fields of research

Scientifically, there are three objectives: to make possible, to carry out and to maintain the separation phenomena. This will be done in particular by exploiting the conceptual and practical potential of "nano-chemistry".

The Institute's research topics are intentionally defined in order to complement and create synergy with the chemistry of **actinides**, a topic already extensively developed at Marcoule. For more than 15 years, following the "Bataille" Act of 30th December 1991, and the 28th June 2006 Act on the sustainable management of radioactive materials and waste, the teams at CEA have been among the world leaders in the separation sciences for reprocessing-recycling of spent nuclear fuels and for optimizing the production of ultimate waste (in particular by means of feasibility demonstrations performed in the Atalante facility. See *CEA News n°2*, special report on "Solutions for radioactive waste" downloadable from the site).

The Institute's fields of research can be divided into 3 main areas:
- Complex fluids that occur in the production of nuclear materials: emulsions, clays, extractants, complexants, and biological fluids for nuclear toxicology,
- Multiscale materials, for which the first scale is nanometric, hence the term "nano-materials",
- Solid-solution interface between the often corrosive fluids and the above-mentioned materials, in extreme conditions.

For each of these three cross-disciplinary areas involving nanosciences, seven research fields can be identified as being both new and pertinent, in line with the requirements expressed by CEA and its partners, and have been chosen as the fundamental building blocks of the Institute's activities:
- chemistry and physical-chemistry of actinides,
- ions at the interfaces in corrosive media,
- ionic selectivity using self-assembled molecular systems,
- sonochemistry in complex fluids,
- self-repairing nanomaterials,
- interfaces of evolving materials,
- analytical isotopic chemistry.

These topics, which are handled in the Institute's seven laboratories, are supplemented by another three, which are more cross-disciplinary in nature:
- theoretical and environmental chemistry microscopy,
- diffusion / diffraction,
- theoretical chemistry modeling.

The highly innovative nature of this research, in which the chemical phenomena are examined at the nanometric level, means that the advances expected can be put to use in a number of non-nuclear fields: new technologies for energy, information and communication technologies, biotechnologies, etc.

Natural uranium
Natural uranium is made up 99.3% of uranium 238 and 0.7% of uranium 235.

Supercritical fluids
We talk of a supercritical fluid when a fluid is heated above its critical temperature and when it is compressed above its critical pressure. Its physical properties (density, viscosity, diffusivity) are then between those of a liquid and those of a gas.

Atalante
The Atalante facility at Marcoule contains the highly specialized laboratories needed for the work being done on improving spent fuel processing. It was adapted for the performance of studies on the management of high-level, long-lived waste: design and experimentation of extractant molecules and study of advanced separation processes, design and manufacture of irradiation targets for transmutation, studies of the long-term behavior of waste storage and disposal. CEA is also developing processes in the facility for reprocessing and recycling fuels for the future "4th generation" fast neutron power generating systems.

Actinides
All actinides are radioactive elements and take their name from actinium (Z=89), a heavy metal, because they have similar chemical properties. Uranium and thorium, which are relatively abundant in their natural form, owing to the very long half-life of their most stable isotopes, are actinides. The actinides include artificial, or transuranic elements, which are heavier than uranium: these are created by neutron capture not followed by fission.

Shielded Process Chain in Atalante.

EXAMPLES OF STUDIES CONDUCTED BY THE INSTITUTE AND THEIR POTENTIAL APPLICATIONS

Surface studies of new materials

The use of significantly higher temperatures and pressures is being envisaged for the "4th generation" systems. The search for new materials for use in nuclear applications (fuels, structural materials, disposal or storage matrices) must comply with these new objectives. Consequently, the fuel environment in such systems means that the new problems inherent in fuel recycling (through complete and/or targeted dissolution) and the storage and disposal of secondary waste, will have to be resolved. One of the difficulties lies in predicting the long-term behavior of the materials used, entailing understanding the physical-chemical phenomena occurring at the interface between solids and liquids, compounded by the presence of external constraints (mechanical, thermal, chemical, irradiation, etc.). The Institute will have to determine and understand the links that exist between the morphology and microstructure of a solid, on the one hand, plus its solubility (or otherwise), so that it is possible to predict and/or manage the physical-chemical parameters liable to accelerate or slow down this dissolution.

Sonochemistry studies

Sonochemistry is based on the chemical reactions caused by ultrasound acoustic energy. The purpose of fundamental research is to understand the mechanisms behind these reactions, by bringing together theoreticians and experimenters from various disciplines: acoustic physicists, interface chemical physicists, chemists specializing in high-temperature and analysis, etc.

Sonochemical reactions produce very little secondary waste and can be considered to be "green chemistry" processes. Some of them are already being studied as a way of stabilizing micro-bubbles of air, passivating surfaces against corrosion, synthesizing nanoparticles with adjustable properties, or safely manipulating actinide colloids. In the processes that will be used in the nuclear plants of the future, sonochemistry will no doubt play an important role, ranging from fuel dissolution to the preparation of storage nano-materials containing hot, short-lived radioactive waste. At the Institute of Separative Chemistry, a sono-spectrophotometer will be used. This tool is unique in Europe and combines optical spectroscopy, analysis of the gases and reaction products present and monitoring of the acoustic pressure and temperature.

Monitoring a reaction in the ions at interfaces laboratory.

Self-repairing nano-materials

Materials capable of rapid renewal (said to be "self-repairing") are of great interest for the industries of tomorrow. The aim of the research to be carried out at the Institute, is to use the knowledge acquired on the self-transformation of matter at all scales, and the associated physical-chemical modifications, in order to design complex materials whose properties not only refuse to degrade, but can also improve over time. This is primarily focused on multiscale materials, from the nanometric to the micrometric. This implies the ability to synthesize them through the combined use of advances in soft chemistry and precursors with a large specific surface area, in order to obtain controlled reactivity. The reactivity and evolution of these nanostructured materials over time will also need to be characterized and modeled. It will be possible to apply these skills to the production of self-repairing hybrid nanomaterials. The goal in particular is to deposit "adaptive" coats to the surface of materials comprising clearly defined nanostructures and which react to changes in the environment by "repairing" themselves. For radioactive waste matrices, this consists in synthesizing and characterizing new self-organized organic precursors capable of "mineralizing" in the presence of the charged species emitted by the solid subjected to irradiation.

THE TRAINING ROLE OF THE INSTITUTE

The presence of three public higher education establishments within the Institute (University of Montpellier 2, the Montpellier Ecole Nationale Supérieure de Chimie and the National Institute for Nuclear Science and Technology (INSTN)) will ensure that fundamental research, training through research (young doctoral or post-doctoral researchers) and higher education (including research Master's and professional degrees in chemistry from the Montpellier chemistry hub) are closely intertwined.

Through the close involvement of its many researchers and engineers, the Institute is an active participant in setting up and providing teaching on subjects of interest to the nuclear industry: separative chemistry, radiochemistry, physical-chemistry of actinides, materials chemistry.

Every year, the INSTN branch in Marcoule receives 2,000 people for continuing professional education classes in the following fields: radiation protection, safety, work in a nuclear environment, decommissioning and chemistry. The INSTN also takes part in training students, through joint diplomas or via special agreements with universities, in order to propose higher education curricula tailored to the new nuclear issues.

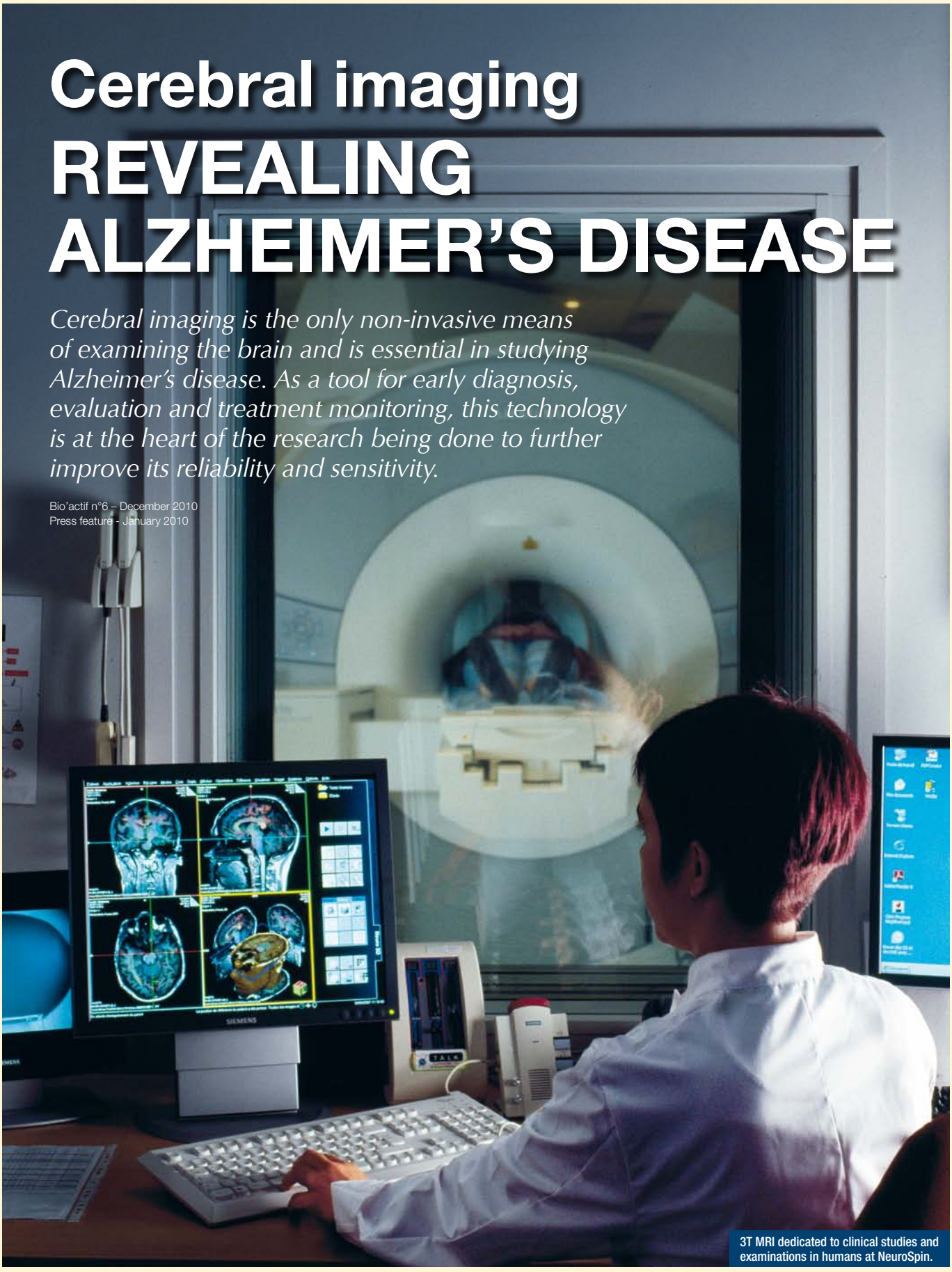
/// RESEARCH

/ Alzheimer diagnosis and treatment / NeuroSpin / Neuro-imaging techniques

Cerebral imaging REVEALING ALZHEIMER'S DISEASE

Cerebral imaging is the only non-invasive means of examining the brain and is essential in studying Alzheimer's disease. As a tool for early diagnosis, evaluation and treatment monitoring, this technology is at the heart of the research being done to further improve its reliability and sensitivity.

Bio'actif n°6 – December 2010
Press feature - January 2010



3T MRI dedicated to clinical studies and examinations in humans at NeuroSpin.

/ THE FIRST SIGNS OF ALZHEIMER'S DISEASE

Between 10 and 20 years. That seems to be the time during which there is slow degeneration of the brain associated with Alzheimer's disease, even before the appearance of the first signs of dementia which lead to the diagnosis. This is why researchers are using every means at their disposal to find the early warning signs of this pathology in the blood, the cerebrospinal fluid and the brain itself, which can now be observed in detail thanks to cerebral imaging.

In this disease, the degeneration is manifested by two types of lesions identified by Doctor Alois Alzheimer in the early 20th century. On the one hand, the "amyloid plaques", abnormal aggregates of a protein called Beta A4; and on the other, "neurofibrillary tangles" an aggregate of the tau protein, this time in the neurons, preventing them from working before leading to death. Given that these lesions are irreversible, the pharmaceutical industry is attempting to delay their spread, which leads to dementia. But for drugs to be effective, a diagnosis must be established even before the patient exhibits the first symptoms.

Improving the diagnosis

Positron Emission Tomography (PET) could be a useful tool in doing this, because it is a tool that can both detect and quantify. This technique consists of attaching a radioactive molecule to a **biological marker** of the disease and then measuring the radioactivity in order to show where the molecule became attached and in what proportion. This radioactive molecule, intravenously injected into the patient, is called a radioactive tracer. Some already exist, such as **PIB**, for example to visualize the amyloid plaques. At present the Service Hospitalier Frédéric Joliot (**SHFJ**) is running clinical trials of this tracer, in collaboration with the Pitié Salpêtrière hospital.

PET examination in the SHFJ.

One of the drawbacks for widespread use of PIB is that it is marked with carbon-11, a radioactive element with a life of only 20 min, which means that it has to be produced *in-situ*.

The problem is that few nuclear medicine centers have the necessary equipment or know-how for this production. Louisa Barré's team in the **CI-NAPS** unit in Caen, developed a synthesis method compliant with French regulations, for another radioactive tracer: AV45. This is marked with fluorine-18 and has a life of about 2 h, enabling it to be transported. It is currently the basis of two clinical trial protocols being run in partnership with the Inserm's research units.

No marker is as yet able to provide a reliable early diagnosis and only a combination of corroborating data can be used to estimate the probability of the patient developing Alzheimer's disease in the near future (two to three years). The staff at **MIRCen**, the SHFJ and NeuroSpin (see page 14) worked on another approach by developing DPA714, a radioactive tracer of activation of the microglia, the cells which clean the brain when a neuron dies. This phenomenon is not specific to Alzheimer's disease, but its observation in certain areas of the brain could confirm the diagnosis.

Producing a radioactive tracer is no mean feat. First it must be synthesized and the researchers then have to make sure that it is not toxic, understand what happens to it in the blood and identify where it attaches.

Furthermore, amyloid plaques are not conventional targets for this type of examination. *"They are aggregates and not specific receivers on the surface of a cell. Many other neurodegenerative diseases exhibit relatively similar aggregates, hence the difficulty in finding markers that can reveal this disease"* adds Philippe Hantraye, director of MIRCen, whose team is currently attempting to develop a new model of the disease in primates which, among other things, would allow verification of the metabolism *in vivo* and of the selectivity of the radioactive tracer or of a possible treatment.

To make things more complicated, as we are dealing with imagery of the brain, the molecule has to be able to cross the barrier which isolates the brain from poisons: the blood-brain barrier. A simple test was developed at the SHFJ for *in vitro* detection of whether or not the molecule of interest passes this barrier. As regards the DPA714, the teams from **I²BM** are waiting for authorization from the French health products safety agency (AFSSAPS) to begin clinical trials.

Alzheimer's, a real social issue

In France, Alzheimer's and similar diseases progress inexorably with age: as of 85 years old, 1 in 4 women and 1 in 5 men are affected.

Weighing a sample for analysis in the preparation of radiopharmaceuticals in the SHFJ.

Another technique that could be used is Magnetic Resonance Imaging (MRI), which reveals changes in the structure or substance of the brain. For example, using this technique, the CI-NAPS team associated a pronounced acceleration of the appearance of lesions in the white matter with symptoms of dementia.

To reach this conclusion, it was necessary to manage the acquisition and processing of data obtained from 10,000 subjects more than 65 years old, then develop software to detect this acceleration in the appearance of lesions.

A promising tool

Cerebral imaging of this pathology requires detailed and complex analysis. Unlike cancerology, for which the objective is to determine whether or not a tumor is present, here the goal is to identify very small volume variations in clearly determined areas.

For example, one of the indicators of the disease is a reduction in the volume of the hippocampus, an area smaller than a thimble, located deep inside the brain and particularly involved in episodic memory lapses.

For the purposes of an early diagnosis, the expertise of the radiologist is now reaching its limits and the analysis requires computer processing. Automation however means standardization of acquisition protocols and this is one of the aims of the Image Acquisition and Processing Center (CATI), a consortium that has set itself the goal of creating a bridge between clinical research and research into image processing algorithms. CATI has just been launched as part of the national **Alzheimer Plan**, and its aim is to achieve tangible technology transfer to the hospital world.

In concrete terms, CATI is working in two key areas: on the one hand, to centralize the evaluation of the quality and analysis of the PET and MRI images acquired by a network of partner radiology and nuclear medicine centers; on the other, to enable the pharmaceutical industry to access clearly identified patients. In order to check the effects of a drug on Alzheimer's disease, the patients testing it must actually be suffering from this pathology and not from another one with similar symptoms. Beforehand, however, pre-clinical tests are essential if a treatment is to be validated. This is a highly selective step during which one in three candidate drugs fail. MIRCen chose imaging so that the same techniques for evaluating their effects can be used on both animals and man, thus leading to time, efficiency and money savings and advances in ethical terms with respect to the protocols. The main difficulty is to find signatures in animals that are equivalent to those that can be seen in man. MRI protocols were thus established to visualize atrophy of the hippocampus in the Lemur.

MIRCen's expertise makes it the ideal choice for running the last pre-clinical tests preceding the clinical trials phase. It is therefore currently evaluating four treatments. Depending on the results, the molecules will be tested on humans and evaluated using the same imaging protocol.

Result of an MRI examination at NeuroSpin.

Biological marker
Measurable physiological change signaling the appearance of a pathology or of a certain stage in this pathology. This marker should ideally be specific to the disease being studied.

PIB
The radioactive tracers used in research are generally designated by their code name given by the laboratory which developed them.

SHFJ
Service Hospitalier Frédéric Joliot, dependent on the CEA and located in the Orsay Hospital near Paris.

CI-NAPS
Centre d'Imagerie – Neurosciences et d'Applications aux Pathologies.

MIRCen
Pre-clinical research center for neurodegenerative, cardiac, hepatic and infectious diseases. Its purpose is to design, validate and evaluate new therapeutic strategies.

I²BM
Biomedical imaging institute comprising SHFJ, NeuroSpin and MIRCen.

Alzheimer Plan
This plan was launched on 1st February 2008 by Nicolas Sarkozy, for the period 2008-2012 and has been granted specific resources. It focuses on the sick person and his or her family and its objective is to make an unprecedented effort on research, to promote earlier diagnosis and to provide better care for patients and their helpers.

APPLICATIONS

A Franco-Swiss license

CEA has just awarded an evaluation license to the Swiss company PMOD, the largest independent company in the field of software for analysis of images obtained by Positron Emission Tomography. PMOD will therefore be evaluating the commercial potential of two new software programs developed by the researchers at the SHFJ. This software will determine the radioactive concentration of the tracer in the regions of interest, with a precision of about five per cent. The potential reward is enhanced discrimination of tumors. This agreement could eventually become a commercial license.

Whole body image of a patient during a PET examination in the SHFJ.

/ NEUROSPIN: A LARGE CEREBRAL NEURO-IMAGING INFRASTRUCTURE

Biomedical imaging is today faced by a number of technical constraints severely restricting its potential. With NeuroSpin, CEA has a large biological instrument that should enable it to push the exploration envelope by means of imaging tools of unprecedented power. The physical technique chosen is intense field nuclear magnetic resonance.

Better understanding of the human brain: how it grows, how it works, is one of the major challenges of the 21st century with enormous stakes for society. Over and above the benefits in the health and neurosciences fields (progress in neuro-surgery, neurology and psychiatry, and so on), understanding the brain gives a clearer idea of how individuals interact with each other and with their environment, opening the door to progress in the fields of communication, education, ergonomics, etc.

NeuroSpin is a large research infrastructure designed to push back the current limits of cerebral imaging. The levels of performance achieved will make it possible to observe the brain and its pathologies even more precisely, on a scale more representative of the cellular and molecular phenomena controlling it.

Non-traumatic neuro-imaging methods, such as MRI, do not interfere with brain functions and enable the human brain to be examined in patients and healthy volunteers. Yet MRI has come nowhere near reaching its limits: by increasing the magnetic field of the magnets, one can hope to boost the spatial or temporal precision of the images by a factor of five to ten. In this way, it would be possible to study the working of the brain at a scale of a few hundred or a few thousand neurons (rather than millions as at present), an intermediate scale which could hide a "neural code" in the same way as there is a genetic code.

A level of power unequalled anywhere in the world

While medical MRI scanners generally have a power of 1.5 **tesla** (T) (30,000 times the Earth's magnetic field), NeuroSpin is already equipped with two magnets of 3 and 7 T (140,000 times the Earth's magnetic field). The second one, which is unique in France, already offers a level of sensitivity far superior to that of "standard" MRIs. In 2013, NeuroSpin will have an 11.7 T magnet, representing a level of power unequalled anywhere in the world. This exploit is due to the originality of NeuroSpin's situation within CEA, which brings the highest level methodologists and neurobiologists together in one place. This magnet is currently being built by the CEA physicists, who also built the magnets for the LHC at the CERN in Geneva, as well as the magnets for ITER.

View of the NeuroSpin Galeria.

THE WORLD'S MOST POWERFUL MAGNET

The researchers at NeuroSpin, the neuro-imaging unit located in CEA's Saclay Center, have been waiting for this moment for a long time: the world's most powerful magnetic resonance magnet (17.2 teslas) was successfully tested in November 2010. It is intended for the study of the brains of rodents.

Journal de Saclay n°49 – December 2010

To meet today's cerebral imaging challenges, permanent dialogue between those who develop and those who use these instruments is essential. It is precisely this combination of different yet complementary know-how and skills, of public and private researchers, engineers, doctors and technicians that underpins the basis and the originality of NeuroSpin. This infrastructure, opened in 2007, is one of the rare institutions in Europe, if not the world, able to bring these experts together in the same place, whether from organizations (CEA, Inserm, INRIA, CNRS), universities or engineering colleges, private industrial laboratories, or other foreign institutions in Europe, the USA or Asia, to design, build and use magnets of a power hitherto unprecedented.

At the crossroads of scientific and technological knowledge and know-how, NeuroSpin, the Service Hospitalier Frédéric Joliot (SHFJ) at CEA Orsay and MIRCen, the pre-clinical imaging center set up at CEA Fontenay-aux-Roses, constitute a pooling of biomedical imaging resources and expertise that is unique in the world today.

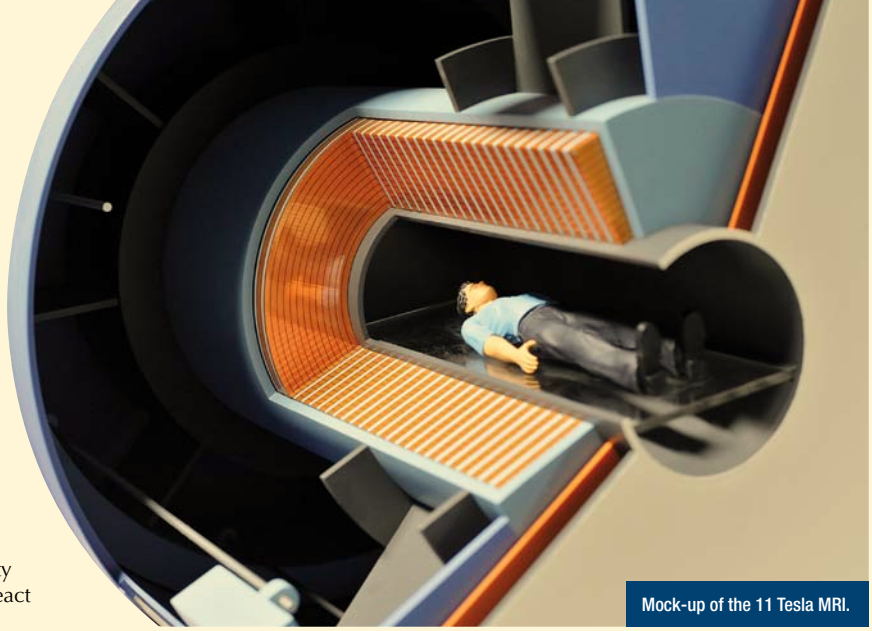
At a European level, NeuroSpin is a founder member and the French representative of EATRIS, the European infrastructure network within the framework of **ESFRI**, and is able to host teams from around the world for brain imaging studies. NeuroSpin is also the cornerstone of a highly ambitious Franco-German R&D program called "Iseult", piloted by industry (Guerbet in France, Siemens in Germany) and funded 50% by industry and 50% by **Oséo** in France and the **BMBF** in Germany. This project concerns the development of very strong magnetic field MRI molecular imaging for early diagnosis and therapeutic treatment of patients suffering from Alzheimer's disease, cerebral infarctions or brain tumors.

The NeuroSpin concept

This is organized around three complementary, interconnected approaches:

- Instrumentation: In addition to the 3 T and 7 T MRI scanners, and the future 11.7 T magnet, NeuroSpin has since 2010 had a 17 tesla MRI system at its disposal for studies on small animals. NeuroSpin is also equipped with a magnetoencephalography (MEG) system for recording the infinitely small magnetic fields naturally produced by the brain.
- Modeling: Modeling (mathematical, physical, physiological, etc.) of brain functions demands cooperation by a range of skills and considerable computing power in order to handle, process, model and archive very large volumes of data concerning thousands of patients. Specific software has to be produced to extract pertinent information from these data, allowing improved individual detection of anomalies so that an early or even preventive diagnosis can be made, or to allow real-time monitoring of the effects of a treatment.
- Validation and applications: The NeuroSpin platform comprises two sectors, clinical and pre-clinical. A medicalized area with beds and medical personnel can receive hospitalized patients, in close collaboration with the hospitals. The pre-clinical area is used to study transgenic mouse lines to establish how assemblies of neurons develop and become organized according to the environment and the expression

of genes or pathologies such as Alzheimer's disease or brain tumors. This step is essential before these models can be used to understand human cognitive processes, their pathologies and their therapies. It must therefore be possible to study the entire continuum, from the mouse model to man, in parallel and with the same imaging methods. One of the objectives of NeuroSpin is to better understand the respective roles of our genes and of the environment in the anatomical and functional development of our brain, both normal and pathological. The "neural code" must therefore incorporate this two-fold ability to respond to a genetic heritage (genetic code) and react to the environment.



Mock-up of the 11 Tesla MRI.

Neuro-imaging techniques

These techniques are used for both research and diagnosis and aim in particular to:

- Provide increasingly accurate maps of the brain areas in which the cognitive functions take place. They can distinguish between assemblies of neurons and the mental processes involved in language, memory, calculation, preparation for action, learning to read and even consciousness.
- Understand the pathways and the mode of processing information in the brain, by visualizing the order to activate regions of the brain for processing information and by showing the bundles of connections and the connection "hubs" that allow transmission of the activation between the different cerebral regions.
- Elucidate the "neural code", in other words, find out how information is coded and processed in the brain. In the same way as the genetic code, this coding relies on assemblies of atoms making up the DNA and must be hidden in a highly-structured spatial organization of neurons. At the same time, this organization must be highly flexible so that it can adapt to the environment and to learning during the development stage and indeed the entire lifetime of the person.
- Understand psychiatric cerebral pathologies (schizophrenia, autism, addictions, etc.), neurological diseases (multiple sclerosis, epilepsy), neurodegenerative diseases (Alzheimer's, Parkinson's) or development anomalies (dyslexia, dyscalculia), so that they can be better recognized, prevented and treated.

Research programs

The research projects being developed at NeuroSpin are multi-disciplinary and cover four main areas:

- Instrumentation and methodology designed to improve existing MRI scanners, develop new anatomical and functional imaging methods using MRI, study of molecules other than water (virtually the only one used today), in particular carbon or phosphorus based molecules, etc.
- Modeling of the anatomy and functions of the brain, involving new algorithms, the use of large databases, merging of MRI data with other methods (electro-encephalography, magneto-encephalography, etc.) and the use of supercomputers and computational grids.
- Applications aimed at understanding certain pathologies (epilepsy, neural migration anomalies, cancers, neurodegenerative diseases, Alzheimer's, Parkinson's, development and genetic disorders, etc.). The aim is to more clearly identify the relationships between genes and environment in cerebral plasticity, and to understand the brain mechanisms (physical, chemical or biological) involved in the cognitive and mental processes.
- Study of the possible effects of magnetic fields and electromagnetic radiation on biological tissues and organisms.

Myriad spin-offs are expected

The foreseeable offshoots for this large national instrument are scientific, clinical, industrial and economic:

- The technological obstacles overcome with these new magnets will be able to modify current concepts and help develop clinical MRI scanners. The algorithms and computing resources developed will benefit a network of neuro-imaging sites distributed around the country.
- The development of new tracers and contrast media appropriate for such field powers is already under way (Iseult project). These will be able to highlight pathologies at a very early stage (Alzheimer's, strokes, brain cancers) and target the treatment more precisely (molecular imaging).
- The models and tools developed will first of all benefit health care systems and thus patients, with the spin-offs they may have for diagnostic or therapeutic imaging protocols. It should be remembered that about ten years is often needed between the first scientific publication of an innovative idea or industrial patent and its routine clinical use. One of the goals of NeuroSpin is precisely to speed up this translational neurological research so that the patients can benefit from the innovation faster, by involving industry at all levels.

A European infrastructure with an international dimension

Functional imagery is a rapidly expanding discipline. Research in this field is growing and becoming increasingly varied. New methods are regularly appearing and its use in hospitals is expanding and intensifying.

As a large biomedical research instrument, NeuroSpin is a prime candidate for collaborative programs both national (SHFJ and MIRCen at CEA, Inserm, IFR 49, Groupe Hospitalier Pitié-Salpêtrière (AP-HP, AFM), CIERM (Hôpital Bicêtre), Inria, Institut Pasteur, the Génopole in Evry, and so on), and international (Europe, Japan, USA). Structures are in place to receive international delegations.

The national and international scientific community has already expressed its interest in such an installation and about fifteen international teams are hoping to reserve time of from a few weeks to a few months. Highly active discussions and collaborative ventures are in progress, for example: the University of Fribourg and the Julich site in Germany, the University of Leuven in Belgium, the universities of Kyoto and Tokyo in Japan, the National University of Taipei, the University of Minnesota, the National Institutes for Health and the Massachusetts General Hospital in the United States, or the CNRC in Canada.

The physicists at CEA also have the highest level of expertise and benefit from international recognition in the design and construction of superconducting and microwave magnets.

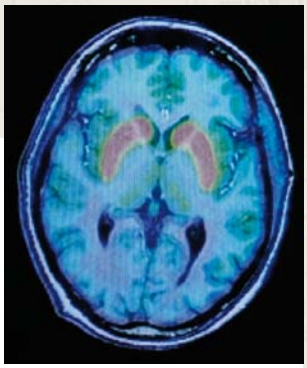
Tesla
The Tesla is the unit of magnetic field. The Earth's magnetic field in Paris is of 0.00005 T.

ESFRI
The European Strategy Forum on Research Infrastructures, is a strategic instrument to develop the scientific integration of Europe and to strengthen its international outreach.

Oséo
As a public establishment, Oséo has three roles: to support innovation, to guarantee funding assistance from banks and investors and to obtain partnership financing.

BMBF
Bundesministerium für Bildung und Forschung.

/ NEURO-IMAGING TECHNIQUES OF TODAY



PET

Positron Emission Tomography

Positron Emission Tomography consists in intravenously administering a molecule marked with a radioactive isotope, in order to externally monitor the normal or pathological functioning of an organ.
The radioactive tracers have the same physical-chemical properties as their non-radioactive counterparts, except for the fact that they have the particular property of emitting radiation. They are thus a means, in conjunction with appropriate detection tools, for following the journey of a previously marked molecule through the organism.
The values thus collected are then analyzed and transformed using a mathematical model, so that an image can be recreated on the screen, representing the position of the radioactive tracer in the organism.
PET is today widely used for physiological and physiopathological cognitive and behavioral studies as well as for the study of various pathologies affecting the central nervous system, such as epilepsy, cerebral ischemia, strokes and neurodegenerative diseases.

MRI

Nuclear Magnetic Resonance Imaging

Nuclear Magnetic Resonance Imaging is a non-traumatic functional investigative imaging method. It uses the phenomenon of nuclear magnetic resonance, a spectroscopy technique discovered in 1946. MRI is based on the use of the magnetic properties of atomic nuclei. It behaves in the same way as magnetized needles which, when an electromagnetic wave of appropriate frequency is applied, change orientation and then emit signals when they return to their original position.
By measuring the very low level of magnetization of the tissues, it then becomes possible to visualize the anatomy of deep and opaque organs, but also and above all the activity of the brain's circuits. This technique produces virtual cross-sections showing the details of the cerebral structures (grey matter, white matter), with millimeter precision. This "anatomical" imaging is used by radiologists to detect and locate brain lesions.

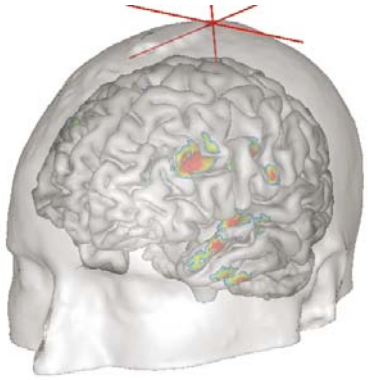
NMR

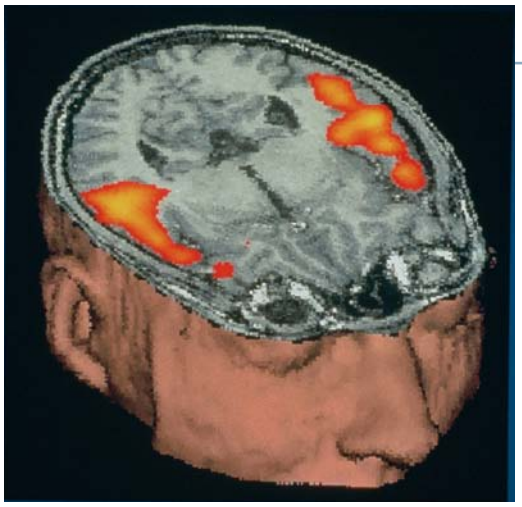
Nuclear Magnetic Resonance spectroscopy

Nuclear Magnetic Resonance spectroscopy, focuses on fundamental molecules other than water and involved in metabolism, neurotransmission or the expression of genes.

Anatomical MRI

By observing the resonance of hydrogen nuclei, which are abundantly present in water and the fats of biological tissues, under the effect of an intense magnetic field, it is possible to visualize the anatomical structure of an organ. This method can be used to diagnose cancerous tumors or to locate certain malformations (for example those causing epilepsy).



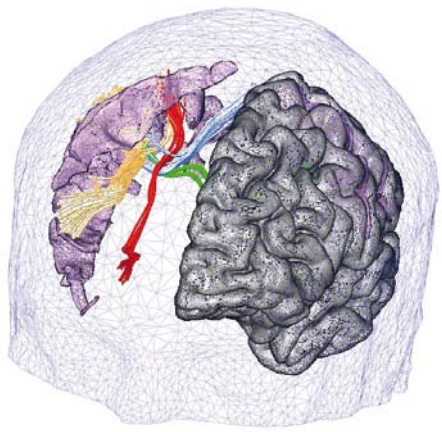


Functional MRI

More recently, thanks to data acquisition and processing speeds, MRI has also become “functional” (fMRI), revealing the activity of the various structures making up our brain.
When we talk, read, move, think, etc., certain areas of our brain are activated. This activation of the neurons entails an increase in the local blood flow in the regions of the brain concerned. It is this local and transient increase in blood flow, rather than the direct neural activity, that can be detected by fMRI, owing to the magnetization of the hemoglobin contained in the red blood cells.

Diffusion MRI

This is a powerful tool for microscopic measurement of movements by water molecules, thus establishing the detailed architecture of the neural tissue and its variations. It offers more direct measurement than the imaging methods conventionally used. It can be used to probe the tissue structure at a microscopic scale far more detailed than MRI image resolution (millimeter). It is also faster because the fall in the water diffusion coefficient appears a few seconds before activation is detectable using functional MRI.



Artist's impression of the Herschel satellite.

ASTRONOMY

Five distant galaxies

detected by Herschel

An international team of astronomers, including a number of French researchers, has just measured the exact distance of five extremely remote galaxies, using ESA's Herschel space observatory plus ground-based observations, in particular with the interferometer of the Institut de radioastronomie millimétrique (millimeter radioastronomy institute).

The research teams showed that the light from these galaxies must have traveled for about ten billion years before reaching us. To come up with this figure, they first of all developed a new method that, for the first time in the submillimeter domain, uses a phenomenon called "gravitational lensing", a sort of cosmic magnifying glass that can be detected by Herschel. These rapidly evolving and remote galaxies had hitherto been hard to observe yet constitute one of the keys to a better understanding of the history of the galaxies in our Universe.

The "gravitational lens" phenomenon

Albert Einstein had predicted the "gravitational lens" phenomenon: when light passes close to an extremely massive object, such as a galaxy, its path is bent. If a galaxy is situated in perfect alignment between ourselves and the very distant galaxy we are observing, the light from the furthest object will then be amplified. This gravitational lens phenomenon is the equivalent of a cosmic magnifying glass and enables us to observe particularly distant galaxies, receiving the light emitted when the Universe was only 10 to 20% of the age it is today.

The international collaboration being coordinated by Mattia Negrello (The Open University, GB) and involving 89 other astronomers, 7 of whom are working in French laboratories supported by the CNES, used the SPIRE and PACS panoramic cameras fitted to Herschel, whose instrumentation was to a large extent developed in the CEA and CNRS laboratories. For the very first time, researchers have been able to observe large swathes of the sky.

Each of the images produced by the international Herschel-ATLAS project contains tens of thousands of galaxies. Most of them are so remote that their light took billions of years to reach us. Based on the initial results of this panoramic survey (1/30th of the total area that will be covered by the end of the project), the team focused on five exceptionally bright objects, which are gravitational lenses. By scanning the position of each of them with large optical telescopes on the ground, the astronomers found galaxies that should not normally have been bright at the wavelengths observed by Herschel. It was therefore highly probable that these galaxies, situated at moderate distances and seen in visible light, were in fact gravitational lenses amplifying the light coming from far more distant galaxies revealed by Herschel using submillimeter wavelengths.

MATERIALS

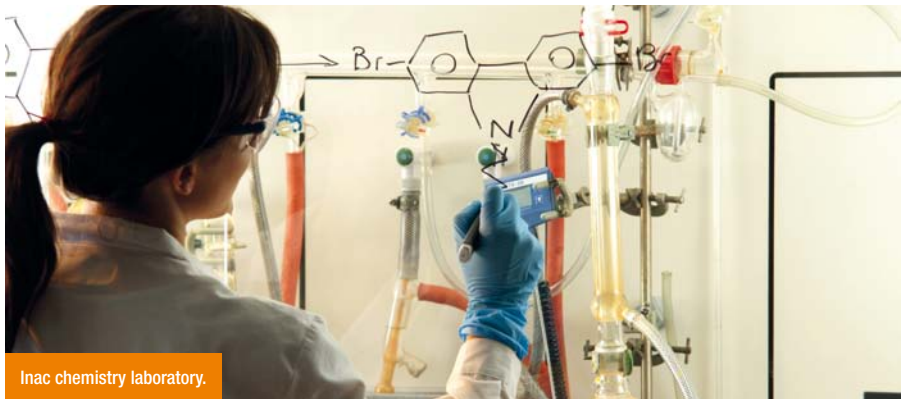
DIAMONDS GET UNDER YOUR SKIN

Sensitive, reactive and biocompatible, the diamond is an ideal material for a range of devices with numerous functions. This is the case with electrochemical bio-sensors comprising an electronic substrate, the surface of which is covered with diamond, onto which bio-receivers (enzymes, antibodies, DNA) are fixed and transmit a signal as soon as they detect a target molecule. However, to ensure optimum operation, the bio-receivers must be firmly attached to the substrate while at the same time remaining active. A **recently patented** solution was found at CEA-**Inac**:

"By hydrogenating the surface of the substrates, we created **covalent bonds** *between the diamond and the bio-receivers. The diamond is first doped with boron and can also act as an electrode. Some bio-receivers can therefore, in addition to detecting a molecule, catalyze their oxidation, which produces electrons captured by the diamond",* explains Pascal Mailley, a researcher whose team has already demonstrated electron transfer between molecular probes and diamond.

It is very easy to produce the bio-sensors thanks to the surface chemistry developed: simply wet the diamond at ambient temperature with the solution containing the bio-receivers. In just a few minutes, they attach themselves to the substrate and the sample can be analyzed. The other advantage of this extremely quick method is to be able to graft a bank of bio-receivers in a single operation, thus being able to detect several target molecules simultaneously. In addition to medical applications (detection of **synaptic activity**, medium for cell networks), these materials modified by biological entities could be used in electronics, or even in the field of energy (bio-fuel cells).

Aude Ganier - Les Défis du CEA n°154 – October 2010



Inac chemistry laboratory.

Recently patented
Jointly with the Néel Institute, the Joseph Fourier University in Grenoble and a CEA-List team in Saclay.

Inac
Nano-sciences and cryogenics institute.

Covalent bonds
Extremely strong chemical bond resulting from the sharing of electrons by two chemical elements.

Synaptic activity
As the substrate functions as an electrode, it can detect neurotransmitters and thus interrogate the synapse (contact zone between neurons).

A ten billion year journey

The astronomers were then able to detect the galaxies in the foreground but above all prove that in each line of sight there were two perfectly aligned galaxies at different distances. The distance of each of these galaxies was measured using spectral shift towards the **millimeter range** of a line emitted by the carbon monoxide molecule, the marker for these galaxies. The **IRAM** interferometer played an important role in these measurements, proving that the light from these objects must have traveled for about ten billion years before reaching us. Its considerable sensitivity, its angular resolution power, as well as recent developments in instruments, should allow precise measurement of the distance to these far objects, identification of the properties of the dense matter (by observing the emission of dust and molecular gas) from which stars are formed and study of the morphology and dynamics of these galaxies at the remotest confines of the Universe.

Press release - November 2010

Submillimeter
Wavelength of 60 to 500 microns.

French laboratories
Paris astrophysics institute, (CNRS/UPMC); Space astrophysics institute (CNRS/Université Paris-Sud 11); Millimeter radioastronomy institute (CNRS/MPG/IGN); Marseille astrophysics laboratory (CNRS/Université de Provence); Astrophysics, instrumentation and modeling laboratory (CEA-Irfu/ CNRS/ Université Paris Diderot).

Herschel-ATLAS
Astrophysical Terahertz Large Area Survey is the largest key-program for "Open Time" satellite observations. It was granted 600 hours of Herschel observing time, for observation of 550 square degrees of sky in 5 bands (110, 170, 250, 350, and 500 micrometers). About 250,000 galaxies are expected to be detected, distributed more or less equally between the relatively near Universe and the very distant young Universe. The program is being run by S. Eales (Cardiff University) and L. Dunne (Nottingham University).

Millimeter range
This phenomenon is comparable to red shift in the visible spectrum.

IRAM
The IRAM was founded by the CNRS in France and the Max-Planck-Gesellschaft in Germany, and then joined by the Spanish Instituto Geográfico Nacional. It comprises a 30-metre diameter radiotelescope at Pico Veleta in Spain, and an interferometer consisting of six 15-metre diameter antennas on the Bure plateau in France.

These results are published in Science magazine of November 5, 2010.

Galaxy G299 seen by Herschel.

TECHNOLOGIES FOR INFORMATION

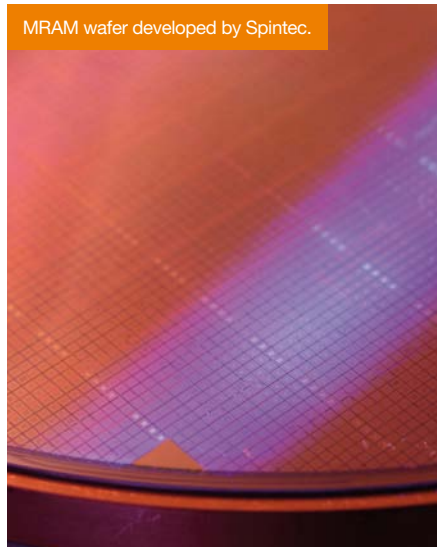
DATA STORAGE

"We are all looking for the same thing, to be able to store more information on the same area, while retaining a good output signal and realistic production costs," explains Jérôme Moritz, researcher at Spintec (joint CEA-CNRS laboratory), part of the Inac. CEA, along with other laboratories around the world, has since 2000 been working on computer memory media that are not made of a continuous layer of magnetic material, but of nanometer scale silicon "dots" covered with a fine magnetic layer. Each dot stores a data bit (0 or 1) according to the direction of its magnetization: up or down. The next step was logical: why not superpose several magnetic layers, so that more than one bit per dot can be stored?

CEA tested superposed, twin-layer perpendicular magnetization (up/down) systems. However, when the read head passed over the dot, the signal from the upper layer tended to mask that of the lower layer. Two stacked layers were tested: one with perpendicular and the other with planar magnetization. The read signal from this latter appears above all around the periphery of the dot rather than in the centre, as is the case with perpendicular magnetization. The technology looked promising on paper and confirmed its potential during tests. It is thus possible to store and read two bits instead of one on a dot measuring 140 x 80 nanometers. The challenge now is to develop an industrial technology for printing the entire surface of a 3.5 inch hard disk, given that the laboratory tests concern very small surfaces.

Patrick Philippon - Les Défis du CEA n°155 – November 2010

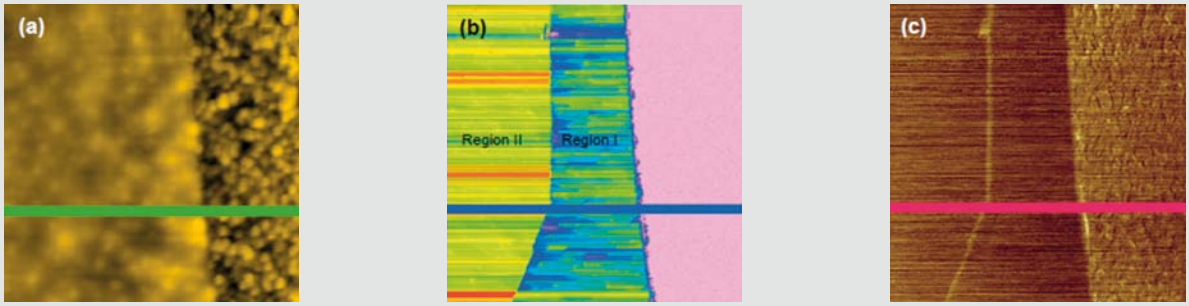
Inac
The CEA Institute for nanosciences and cryogenics conducts research into nanosciences, condensed matter, cryogenics and the development of research tools.



MRAM wafer developed by Spintec.

MOLECULAR CHEMISTRY

NANOTAPE, it really sticks



Atomic force microscopy images showing three different modes of a graphene sheet immobilized by nanotape. On the left, the edge of the sheet and significant roughness of the gold substrate. In the centre, electrical resistance measurement between the substrate and the surface, the pink area (corresponding to the substrate) being extremely isolating. On the right, boundary between the two graphene zones of different thicknesses.

It sticks everywhere and can attach almost anything! The "varnish" developed by the researchers at the CEA-Iramis not only has the ability to chemically bond with all types of substrates, but also to attach a large range of molecules, without modifying them. This should pave the way for a variety of applications in the biotechnologies and molecular electronics fields.

A large number of laboratories specializing in materials treatment are attempting to find a way of depositing molecules on surfaces, in order to change their properties for example. The problem is that in order to "attach" these molecules by chemical bonds, the scientists often have no choice but to modify them slightly, with the ever-present risk of altering them. This is particularly problematical when dealing with extremely fragile proteins or DNA.

Hence the idea of developing a universal coating onto which any molecule could be attached, without modification. This is what the researchers at CEA have actually managed to achieve. They discovered a diazonium salt precursor which behaves like double-sided adhesive tape. When it is applied to a surface, this amine reagent chemically adheres to the substrate. Then, following appropriate treatment it can attach a large number of complex molecules, without degrading their active functions: nanotubes, graphene sheets, biological materials. This universal bonding ability has resulted in the filing of several patents. It could also be extremely useful for certain highly specialized tasks such as immobilizing DNA strands in bio-chips or connecting nanometer-scale circuits.

Vahé Ter Minassian – Les Défis du CEA n°156 – December 2010

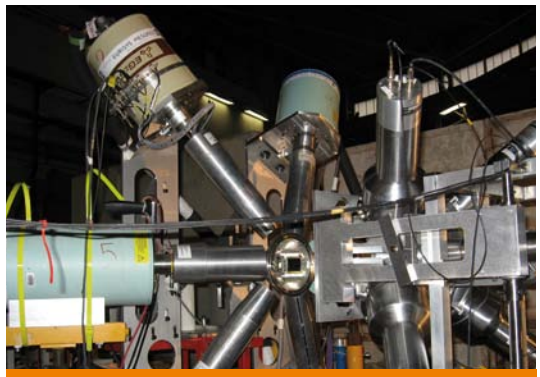
Iramis
Saclay Institute of Matter and Radiation.

NUCLEAR SCIENCE

UPCOMING EXPERIMENTS on Spiral 2

New experiments are being prepared on Spiral 2, at the Ganil in Caen. They should provide nuclear data on hitherto inaccessible fission fragments.

Nuclear data evaluations require measurements that are increasingly exhaustive (unstable nuclei, excited nuclei, etc.), more precise and cover a broader energy range. They are carried out using models that are based on measurements, or which need to be validated by them. Of the nuclear data evaluated, the nuclear reaction in which gamma radiation follows capture of a neutron by a nucleus, called the radiative capture reaction, is the hardest to predict, because it varies considerably from one isotope to another. In this process, the nucleus formed after capture of a neutron, called the "compound nucleus", is de-excited by the emission of gamma rays. If the neutron flux increases significantly, successive captures create a multitude of nuclei, some of which will be radioactive.



Experimental "*Surrogate Experiment with XY silicon*" set-up used to study the "compound nucleus".

Studying these reactions experimentally consists of reproducing them by projecting neutrons onto a target. For some radioactive isotopes, produced for example during the fission of uranium, it is impossible to produce a target (life too short and/or excessive radioactivity). A substitute method must then be adopted.

Substitute method

This consists in forming the same "compound nucleus" by involving a stable target (non-radioactive) and a projectile other than a neutron. The nuclear data being looked for can be obtained by measuring the probability of emission of a "compound nucleus" de-excitation channel, together with calculation of the formation of the "compound nucleus".

This technique was developed in the 1970s, to measure fission probabilities on actinides. Its validity, which has been proven for fission, has not yet been demonstrated however for radiative captures.

Acquiring new neutron data

In collaboration with the University of Bordeaux and the Los Alamos and Livermore laboratories, CEA's nuclear states excitation laboratory began testing of this substitute method on isotopes of lutetium. A series of experiments was carried out using the CEA's 4 MV accelerator, the 15 MV accelerator at the Orsay Institute of Nuclear Physics and the Lansce at Los Alamos. This program will study the pertinence and limits of the method using isotopes of lutetium.

The stakes are high for this study, because it could be extended to measuring neutron reactions on fission fragments. However, these are so far removed from the stable nuclei that it is impossible to find non-radioactive targets for the substitute reactions. The idea is to invert the target and the projectile. The substitute reaction then occurs between a beam of radioactive ions, produced by an accelerator, and a hydrogen target.

As of 2012, the future Spiral 2 project will allow acceleration of fission fragments and enable this type of experiment to be carried out. For example, the installation will be able to produce and accelerate iodine 134, whose half-life is 52.6 minutes. By using a target of deuterium and an isotope of hydrogen, it will be possible to conduct reactions involving the transfer of a neutron from the target to the incident nucleus.

The physicist is faced with a further difficulty: the very low density of a hydrogen gas target. To overcome this, the target must be solidified by cooling it to a very low temperature with the frozen object then maintained without a container so that the beam can interact directly with the hydrogen. A Russian-designed prototype for a target of this type was recently successfully tested on the 4 MV accelerator. This is a world's first. A collaborative venture headed by the Irfu will build a target, called Chymene (French acronym for thin hydrogen target for the study of exotic nuclei), which is to be incorporated into the Spiral 2 installations and be used to run an ambitious and totally unique physics program.

Vincent Méot – Interactif n°55 – October 2010

Spiral 2
2nd generation on-line radioactive ions production system.

Ganil
Large national heavy ions accelerator.

Irfu
Institute of research into the fundamental laws of the Universe.

MATERIALS FOR ENERGY

ALHYANCE INNOVATION, act 2

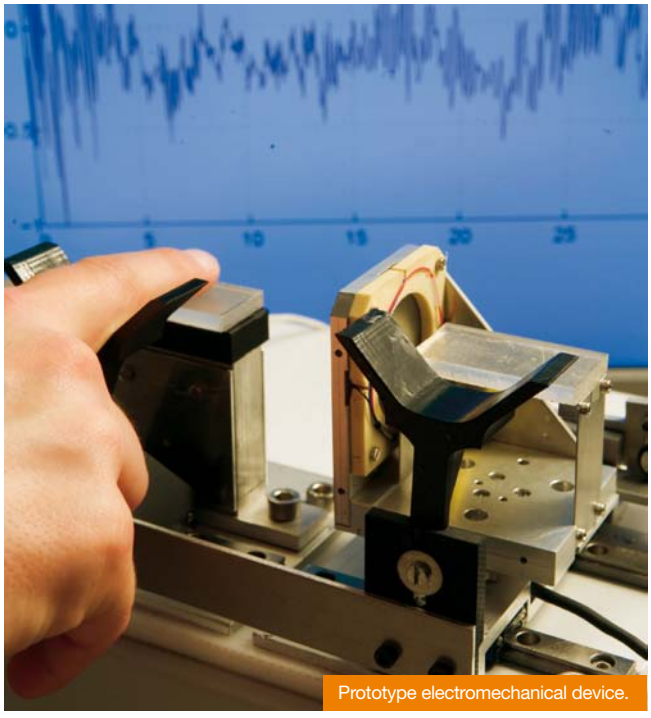
The second Polymers Plastics Composites hub on the AlHyance Innovation platform has been inaugurated at CEA's Ripault centre, near Tours. Its goal is to play an active role in CEA materials research, in particular in the transport field, with the development of batteries and fuel cells for hybrid and electric vehicles. The materials have to meet increasingly demanding specifications with regard to their properties, savings in the manufacturing processes, strength, durability, safety, environmental impact and recyclability.

Les Défis du CEA n°156 – December 2010

Turning out a liner after a reactive rotational moulding cycle.

HEALTH TECHNOLOGIES

Virtual
TACTILE TEXTURES



Prototype electromechanical device.

In 2007, the French national research agency launched the Reactive project, devoted to virtual environments designed to re-educate stroke victims. The CEA-List Institute focused on the tactile part of the project. The research teams first of all met with patients and doctors and then observed the importance of texture recognition in motor function re-education. *"For this, we today only have a few extremely basic games, such as dominos whose surface offers different levels of roughness. We therefore looked for a system which was able to reproduce textures in more realistic virtual environments: at the market, in the home, etc."* explained Michael Wiertlewski.

Existing systems, based on force feedback, re-educate the patient's motor functions but provide only very little tactile information. What was needed was a system able to reproduce the sensation of the skin in order to enhance their content.

When we run our finger over a textured surface, it generates a mechanical vibration that is perceptible to the skin. The laboratory designed an electromechanical device capable of capturing these vibrations and memorizing them, so that they could be reproduced when moving the fingers. The first tests with volunteers demonstrated its ability to "mimic" textures satisfactorily. Using this sensor, the laboratory is at present assembling a "library" of vibration profiles, or in other words textures. These will soon be reproduced with a more compact appliance: a simple actuator of about 2 cm.

Over and above the needs of re-education, a system such as this could become a computer peripheral for applications such as games or on-line sales.

Patrick Philippon - Les Défis du CEA n°155 – November 2010

List
The research done by the Laboratory for Integration of Systems and Technologies concerns embedded systems, interactive systems, sensors and signal processing.

ELECTRICAL STORAGE

When batteries
ARE CONNECTED TO THE GRID

It is one of only six prototypes in the world and is as big as a large shipping container. 10 tons; 4.50 meters long; 2.20 meters wide; 2.4 meters high. But inside, it's just full of energy: 100 kWh and a power output of 15 kW.

"The energy equivalent of 4 to 10 electric car batteries with a range of 100 to 150 km," explains Nicolas Martin, an engineer at INES. This large battery is used for fixed applications. It is connected to a 30 kW photovoltaic unit located on the site. *"The goal is to smooth out photovoltaic production, to avoid disrupting the grid,"* underlines Marion Perrin, head of the Laboratory. This is because renewable energy sources, whether solar or wind, need to be storable so that their intermittent production of electricity – dependent on sunshine or wind – can be matched to the varying demand from the consumers.

The researchers are therefore working on developing a Redox flow battery to meet these needs. They are testing and modeling all the technologies and developing electrical management algorithms to maximize their lifetime.

"Conventionally, the power and energy of a standard battery is linked to the technology, and there's nothing you can do to change that," adds Nicolas Martin. The innovation of this Vanadium redox flow battery system developed or qualified by INES, is to allow separate calculation of the power and the energy. For the time being, the Redox flow system is operational.

Marc Jary - Le Mensuel de Grenoble n°144 – October 2010

INES / LES
Electrical storage laboratory of the INES (French national institute of solar energy).

ELECTRONICS AND INFORMATION TECHNOLOGY

World first:
RYB and CEA-Leti unveil ELIOT®

www.eliot-tech.com to find out more ELIOT®

ENVIRONMENT

"NANOPOLLUTION" *CATALYTIC CONVERTERS*

How can we limit the pollution caused by today's cars until electric cars get her? The solution has been with us for a number of years, using catalytic converters that filter the exhaust gases produced by incomplete combustion of fuel. Their performance could be considerably improved thanks to the work done by a team from the CEA Liten institute, which has optimized the design of these converters. Multi-layer type architecture, superposing a layer of ceramic, catalyst elements and a layer of a precious metal such as platinum, could multiply the triple points, which is where the depollution reactions occur. This process could increase the chemical reactions that transform the gases into less harmful elements, while halving the quantity of precious metals needed.

It is the subtle combination of the three elements that enables carbon monoxide to be transformed into the less toxic CO_2, or the nitrogen oxide into nitrogen and water. The MOCVD system for vapor-phase layer deposition consists of integrating catalysts of a clearly defined size, of between four and fifteen nanometers depending on the application and their type.

The engineers also made sure that these catalysts remain active at low temperatures, so there is no need to inject gasoline into the catalytic converter. This research was carried out under the Decade project, started four years ago with Faurecia and Peugeot PSA. It could also be of interest to other sectors such as ambient air filtering systems.

Aude Ganier - Les Défis du CEA n°155 – November 2010

Chemical vapour phase deposition for a part on which catalyst nanoaggregates are deposited.

Liten
Laboratory for innovation and new energy technologies and nanomaterials.

MOCVD
Metal-Organic Chemical Vapor Deposition.

Decade
Project financed by Ademe.

At the last Pollutec show, the RYB company unveiled ELIOT®, the world's first detectable and communicating plastic pipeline. By integrating RFID type technology developed in partnership with CEA, this pipeline is revolutionizing the safety, monitoring and maintenance of gas, drinking water, wastewater, electricity and telecommunications networks.

By their very nature, plastic pipes are inert and hard to detect once buried. Only topographical surveys are able to situate them. But the urban environment is constantly changing, making it hard to obtain a quick, precise and exhaustive picture of the subsoil. Location techniques are complex and hard to implement. This is why thousands of pipes are accidentally torn up every year, with potentially serious consequences.

In order to resolve this major problem, the RYB company has been working for three years with CEA-Leti. This partnership led to the design and development of the world's first detectable, communicating plastic pipeline, called ELIOT®.

This innovation, specially designed for gas, water, electricity and telecommunication networks, is a real technological breakthrough in terms of piping monitoring and maintenance, thus reducing the risk of accidents and the costs involved in inadvertent tearing up of pipes, but also for advanced traceability of buried infrastructure.

The pipe incorporates a new type of embedded RFID technology developed by CEA and today patented. It has a number of particular characteristics:
- detection down to a burial depth of 1.50 m,
- reliable detection, localization and reading of the information stored on the chip, regardless of the pipe's environment,
- a response time of a tenth of a second,
- information storage capacity,
- an independent system built into the pipe,
- a simple reading system with an appropriate antenna, compatible with off-the-shelf products,
- a signal measured on the surface that accurately characterizes the pipe detected, thus avoiding confusion if several networks are located close to each other.

In concrete terms, special RFID chips are incorporated into the pipe at regular intervals, using a patented process. They are then encoded to carry information specific to each pipe.

Once the prototype was developed, its potential was tested in real conditions on the CEA site, other test sites and on the experimental research platform belonging to the GDF-SUEZ Group, a major operator in the field of gas and water distribution.

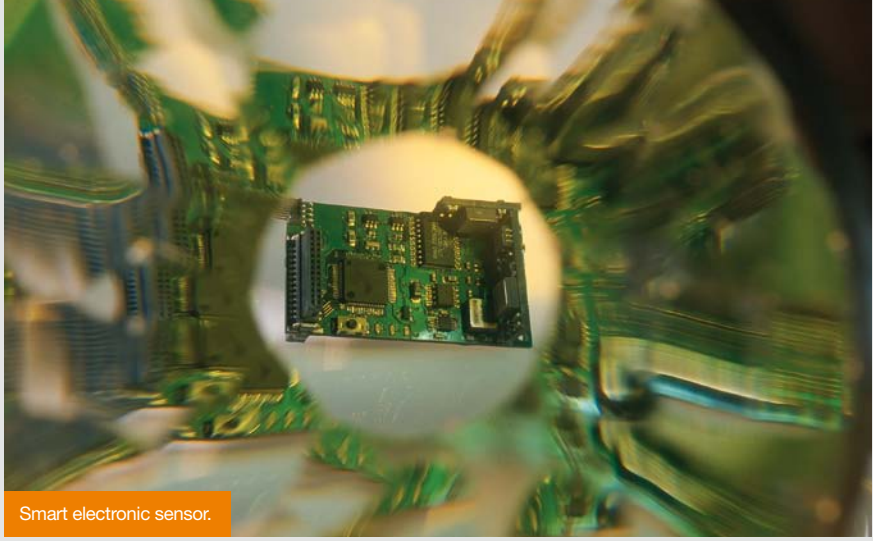
After prototyping and testing on diameters from 63 mm to 125 mm, the RYB company is now moving on to the industrialization phase, in order to expand its range from DN20 to DN1000.

The next step will be to work with the network managers and operators in order to incorporate this technology into their information systems and according to their own specifications. The deployment of trial network infrastructures will also provide interesting feedback for the next phases in the ELIOT® project.

Press release - November 2010

RYB
French leader in polyethylene pipes and networks and a major European player in the transport of water, gas, electricity and telecoms.

Leti
Laboratory for Electronics and Information Technology.



Smart electronic sensor.

COMMUNICATING INDUSTRIAL SYSTEMS

CAPTAUCOM: *three industrial prototypes delivered*

The Captaucom program was launched in 2005 and has achieved its objectives and three independent, communicating prototypes have been developed for three industrial players.

This project focused on developing communicating, independent sensors for the Rhone-Alps based Seb-Téfal, Somfy and NTN-SNR Roulements. Two research organizations, CEA and CSEM, two centers of expertise, Mind and CETIM and technology network Thésame were all involved in the project. The project has just ended with excellent technical results, leading to the production of three prototypes, each meeting the specifications submitted by the partner companies:

- For the Seb group: in the field of measurement and control systems for small domestic equipment, an independent small domestic appliance prototype was developed.
- For NTN-SNR Roulements: in the field of monitoring and diagnosis of rotating parts (transport and industry in general) a prototype independent, communicating monitoring system for bearings was developed.
- For Somfy: in the field of building closure and solar protection sensors and controls (shutters, roller blinds, doors and gates) an independent system for door and window security and monitoring was developed.

These technological advances in miniaturization and reduced electronic component consumption, along with the advent of energy recovery micro-devices, are paving the way for new independent, communicating industrial systems.

Press release – December 2010

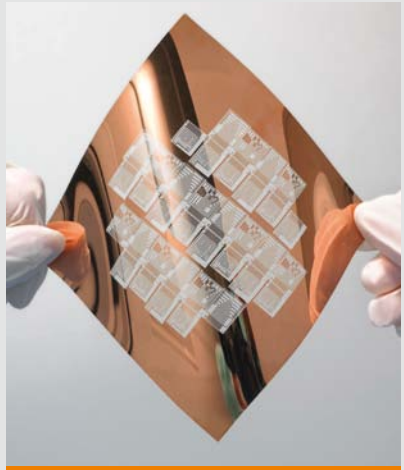
CSEM
Swiss Center for Electronics and Microtechnology.

CETIM
Technical center of the French mechanical industries.

ORGANIC ELECTRONICS

A NEW START-UP AT THE LITEN

Isorg, for Image sensor organic, is the new start-up at the Liten Institute, created in May 2010 and now a spin-off. So what is it all about? It's about printed organic electronics, more particularly transforming glass and plastic surfaces into optical sensors. This is a real breakthrough technology that boasts a large number of applications: industry (photometry, object and shape recognition by image capture), medical (imaging, analysis systems), security (access control), and so on. The first functional demonstrators are now available with one already delivered to a European industrial firm in October 2010.



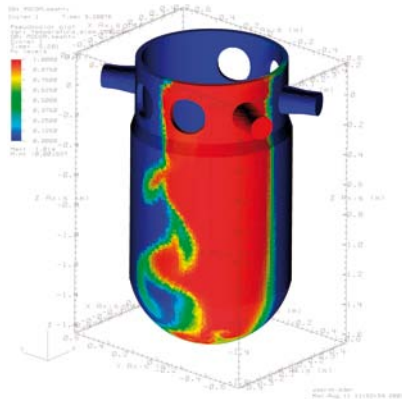
Organic electronics for energy micro-source.

Talents du CEA n°123 – November 2010

MODELING AND NUMERICAL SIMULATION

Inauguration OF THE MANON LABORATORY

The MANON joint research laboratory will enable civil nuclear research to take advantage of the latest mathematical and numerical technologies. It was officially opened on December 17, 2010 by the Chairman of UPMC, Jean-Charles Pomerol, the CEA Chairman, Bernard Bigot and Liliane Flabbée, representing the Chairman of the CNRS, Alain Fuchs.



This laboratory was set up for a renewable four-year period and its aim is to promote research into modeling, numerical simulation and optimization of the complex systems encountered in the civil nuclear industry. Collaboration concerns improvement of the numerical tools currently used and it will above all lead to the production of more powerful numerical methods for better modeling of the physical phenomena encountered in many applications relating to the working of a nuclear power plant.

Thanks to the expertise of the two partners, the MANON laboratory will be able to examine in greater detail and combine the following topics: mechanics of multiphase fluids, multiscale and multiphysic modeling in nuclear reactors, specific numerical methods for neutronics, specific numerical methods for high-performance computing, incorporation of random variables in physical models.

Web release – December 2010

MANON
Modeling and numerical analysis oriented to nuclear energy.

UPMC
Université Pierre et Marie Curie at Paris.

BIOTECHNOLOGIES

Lactose cure

Rhodospirillacea type bacteria are being studied by the research teams at CEA-iRTSV because their photosynthetic metabolism is able to convert certain organic compounds (waste) into hydrogen. This phenomenon is already a well-known one, but the researchers have discovered that this *"production"* of hydrogen worked better when the compound to be degraded was lactoserum. *"The bacteria of the Rhodospirillacea family use lactic acid from the fermentation of milk, to produce hydrogen. However, they are unable to use lactose, a sugar which accounts for 40% of the milk"*, explains John Willison, a researcher. *"We did however manage to incorporate a gene from another organism into the bacterium, so that it could break down lactic acid and lactose."* The scientists therefore placed the bacteria in a culture solution containing whey, plus mineral salts to improve the conditions for photosynthesis. When exposed to incandescent lamps, the brightness of which corresponds to that of the sun, one liter of this culture generated four liters of hydrogen, as compared with two liters with the natural strain of bacterium. The team is now working on optimizing the demonstrator, with the aim of achieving twenty liters within the next two years. The goal is to produce a simple and inexpensive means of producing hydrogen!

Aude Ganier - Les Défis du CEA n°154 – November 2010

Rhodospirillacea
Photosynthetic bacterium which lives in freshwater ponds and lakes.

iRTSV
With its proteomics, high-throughput screening, imaging platforms and animal supply facility, the CEA institute of life sciences research and technologies coordinates the combined CEA, University Joseph Fourier, CNRS, Inserm, Inra research programs.

Photosynthetic growth of the *Rhodobacter capsulatus* bacterium.

PROTEOGENOMICS

Tackling the GENE PROBLEM BACKWARDS

"Sequencing genomes has almost become too easy: the data are building up but annotation is lagging behind", observes Jean Armengaud, researcher at CEA-IBEB. The explanation: decoding the order of succession of the bases making up the DNA is not enough, and the portions with a meaning, in other words, the genes, have to be located in this vastness. Whenever possible, the proteins for which they code must also be identified, along with their function. Given the current rate of production of sequences, this annotation can no longer be carried out "by hand". Computer programs are dealing with this, although the downside is a very high error rate.

Jean Armengaud's team opted to approach the problem in the opposite direction: starting from the proteome (all the proteins secreted by an organism) and working back to the genes. This has the advantage of identifying all the genes, but also their product (the proteins), and therefore frequently their function.

This original approach was applied to *Thermococcus gammatolerans* and *Deinococcus deserti*, two micro-organisms resistant to ionizing radiation, owing to their exceptionally effective DNA repair mechanisms. The results are surprising.

The researchers thus found that certain genes of *D. deserti* had been annotated backwards! They also discovered 19 more than with the previous "classical" annotation. Another finding was that *D. deserti* uses unusual start codons. These are short DNA sequences that give the starting signal for reading of a gene to synthesize a protein and this in particular concerns that which is involved in DNA replication. With regard to *T. gammatolerans*, an organism that is less well-known that *D. deserti*, the same method was used for primary annotation, because nothing hade been done previously. The first significant finding is that the DNA repair mechanisms in *T. gammatolerans* are different from those found in *D. deserti*. In the light of these results, the researchers suggested systematic use of this approach, combining genomics and proteomics, as of the first annotation of freshly sequenced genomes.

Patrick Philipon - Les Défis du CEA n°154 – November 2010

IBEB
The CEA Institute of Environmental Biology and Biotechnology focuses on nuclear toxicology, plant biology and microbiology.

Bacterial growth in an incubator.

BIOLOGY

MICRO-ALGAE but maxi-toxicity

Alexandrium minutum: it is possible that you have never heard this name, but for shellfish and oyster farmers it is all too familiar! It is the most toxic species of phytoplankton affecting the coasts of Brittany and the Mediterranean. The toxins it produces contaminate the mollusks and expose the human consumer to dangerous, sometimes even fatal paralysis. Surveillance of these micro-algae today involves microscope analysis of water samples.

The team run by Fabienne Gas at CEA-IBEB, in collaboration with **Ifremer**, is working on producing new tests and has developed antibodies that specifically recognize *Alexandrium minutum*. The antibody development led to a test, called Elisa, being developed on a microplate: the water samples to be analyzed are distributed around the microplate wells containing the antibody. If an antibody-toxic algae complex forms, this then leads to a yellow stain. One need then simply measure the intensity of the color to deduce the quantity of the complex formed and thus the concentration of micro-algae in the sample. *"This four-hour test gives results similar to the usual surveillance method"*, remarks Fabienne Gas.

The team also used its antibodies to develop a "strip test" employing the same principle as quick pregnancy tests. The micro-algae can then be detected in barely 15 minutes and the test can be carried out directly on-site. Its sensitivity needs to be further improved before the test can become quantitative, but once this is optimized, oyster farmers could use it. Ifremer/CEA collaboration should eventually lead to an in-situ buoy type system for detecting toxic micro-algae species.

Anne Orliac - Les Défis du CEA n°156 – October 2010

Ifremer
Institut français de recherche pour l'exploitation de la mer (French research institute for exploration of the sea).

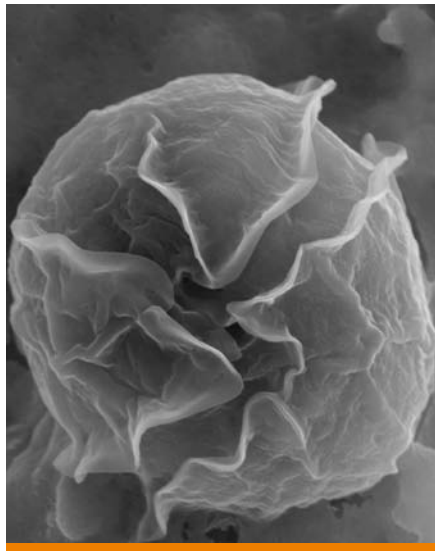
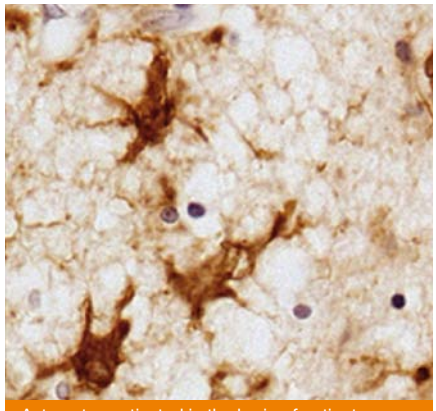


Photo of *Alexandrium minutum* under a scanning electron microscope.

GENETIC THERAPEUTIC RESEARCH

ASTROCYTES: a therapeutic target for Huntington's disease?

Huntington's disease is a neurodegenerative genetic disorder which is still incurable today. Researchers at the **MIRCen** and their American partners have recently identified new possibilities for developing a treatment, by demonstrating that astrocytes, cells that are vital to neuron survival, play a key role in this disease.



Astrocytes activated in the brain of patients with Huntington's disease.

In those suffering from this disease, the huntingtine protein that mutated at the beginning of the cerebral damage is expressed in all the cells of the body. However, it leads to selective loss of neurons in the striatum, but not of other cells such as astrocytes!

What then are the consequences of the expression of the mutated protein in the astrocytes? Thanks to a new **lentiviral vector**, the researchers were able to express the protein only in these cells, in adult mice. They observed abnormal activation of the astrocytes and alteration of the ability to transport glutamate, a property essential to the survival of neurons. These results, found in patients as of the pre-symptomatic stage, make astrocytes new potential targets for development of therapeutic strategies.

Bio'actif n°5 – September 2010

MIRCen
Pre-clinical imaging platform dedicated to the study of neurodegenerative, cardiac, hepatic and infectious diseases, resulting from an association between CEA and the Inserm.

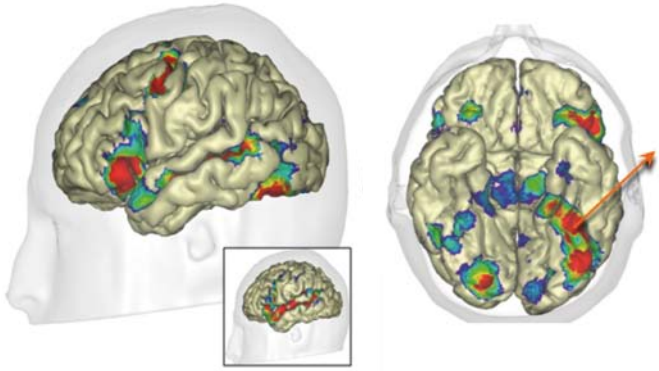
Lentiviral vector
Modified and inactivated virus derived from HIV, enabling DNA to be transferred to the cells.

Faideau M. et al., Hum Mol Genet, August 2010

Preparation of a flow cytometry examination.

NEUROSCIENCES

NEVER TOO OLD to learn to read



A view of the large areas of the brain in which activity increases with the reading score, in response to written sentences. Once a person knows how to read, the response to written words increases rapidly in various visual areas, one of which specializes in analysis of the shape of letters. Furthermore, all the regions in the left hemisphere involved in processing spoken language (inset) are also liable to be activated in response to written language.

What is the impact of acquiring the ability to read on the working of the brain? Writing is too recent an invention to have influenced human genetic evolution and learning how to do it can only involve "recycling" of existing cerebral regions, initially dedicated to other functions. To obtain a clearer understanding of this process, researchers launched a vast **functional MRI** study to compare the cerebral activity of adults with varying degrees of literacy: illiterate, unschooled in childhood but having learned to read as adults, or schooled since childhood. This study was coordinated by the French team and involved researchers from Brazil, Portugal and Belgium. 63 adults took part in it, on the 3 Teslas MRI machines in the CEA Saclay NeuroSpin centre, for the Portuguese volunteers, and in the neurosciences research centre of the Sarah Lago Norte hospital in Brasilia, for the Brazilian volunteers.

The impact of literacy is far more extensive than was originally imagined! Learning to read in fact increases the responses of the visual areas of the brain, as well as the auditory cortex region involved in coding of phonemes, the smallest significant elements of spoken language (such as "b" or "ch").

When learning to read, it is the visual cortex that partly reorganizes itself, through competition between the new reading activity and the older face and object recognition activities. These effects are visible in individuals who were schooled in childhood as well as in those who followed literacy classes when adults, even if these latter only rarely achieve the same reading performance. With these results, the researchers are suggesting that this difference could simply be due to their relative lack of training and that there is no critical age for learning!

Bio'actif n°6 – December 2010

Functional MRI
Magnetic resonance imaging used to determine the brain activity of an individual performing a task.

How learning to read changes the cortical networks for vision and language. Stanislas Dehaene, et al., Science, online, 2010

BIOLOGY

AIDS: the virus can also be transmitted by cells

The virus responsible for AIDS can be sexually transmitted by infected cells present in sperm. This has just been demonstrated for the first time on an animal model by researchers at **iMETI**, the University of Paris-Sud 11 and the Inserm. Sperm contains three major virus sources: infected leukocyte cells, free **virions** and virions associated with the spermatozoa. But are the infected cells as contaminating as the free viruses? This question is an important one when one considers that the sperm of an HIV-positive person can contain a high level of cells infected with HIV. In attempt to find an answer, the researchers used a model of macaque infection by the simian immunodeficiency virus. They thus revealed the important role of cells present in the sperm in the sexual transmission of the virus.

The involvement of infected cells in HIV transmission now has to be confirmed in humans. Understanding how the virus is transmitted by the vaginal mucous membrane is essential in designing new means of protection. In order to circumscribe the Aids epidemic, hope is today being placed on methods other than the condom and which can be more easily controlled by women. If this study is confirmed in humans, these methods should be capable of stopping the virus in all its forms.

Bio'actif n°5 – September 2010

iMETI
CEA Institute of emerging diseases and innovative therapies.

Virions
Viral particle with infectious capability.

Sallé B. et al., J Infect Dis, August 2010

CANCER RESEARCH

A NEW TARGET FOR **ANTI-CANCER TREATMENTS**

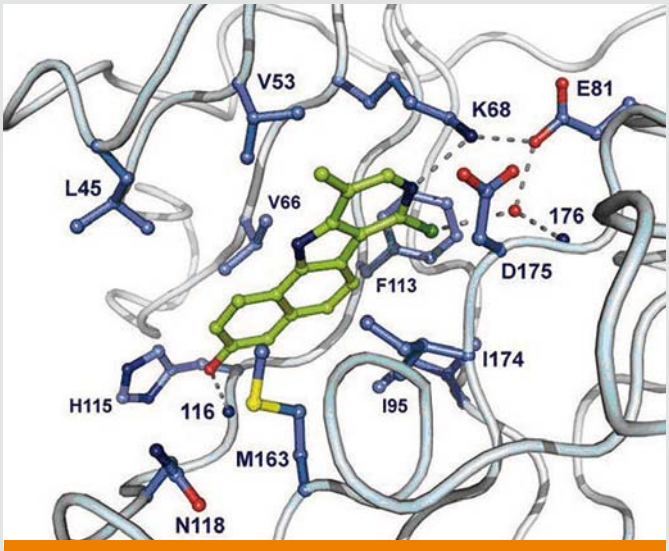
Researchers at the iRTSV, the IBS and the Curie Institute have just identified a new mode of action by ellipticine, a molecule known for its anti-cancer properties, but which is not used owing to its side-effects. By screening the 6,560 molecules in the Curie Institute's chemical library, they selected derivatives of this molecule specifically targeting CK2, a protein kinase found to be deregulated in numerous cancers, and highlighted their anti-tumor potential. These inhibitors are not only capable of preventing the proliferation of cells *in vitro*, but their anti-tumor potential has also been confirmed in mice. Owing to their highly selective mode of action, these derivatives are particularly active but with far less severe side-effects. These results open the door to the design of future cancer treatment drugs, in particular for breast and prostate cancer.

Bio'actif n°6 – December 2010

IBS
Structural Biology Institute.

Curie Institute
State-approved Foundation associating one of the top European cancer research centers with two leading hospitals, together with Inserm and the CNRS.

Renaud Prudent, and al., Antitumor activity of pyridocarbazole and benzopyridoindole derivatives that inhibit protein kinase CK2. Cancer Research, online, 2010



This crystallographic structure shows how a derivative of ellipticine (green) inhibits protein kinase CK2 (blue). The plane structure of this chemical molecule enables it to insert itself into the catalytic site and thus take the place of the enzyme's substrate.

SUPERCONDUCTOR SCIENCE AND TECHNOLOGY

HIGH-TEMPERATURE SUPERCONDUCTORS: is a new magnetic order the origin of the phenomenon?

A little of the mystery surrounding high critical temperature superconductor materials has been lifted: the researchers at the Léon Brillouin Laboratory (CEA/CNRS), working with scientists from the University of Minnesota (USA), have managed to experimentally validate the theory whereby an ordered state of matter exists within these materials, with unprecedented magnetic properties, and which would seem to precede the superconducting phase.

Superconductivity was discovered in 1911 and is the state in which the material is characterized by an absence of electrical resistance and disappearance of the magnetic field. Superconductor materials are thus able to conduct electric current with no energy losses. To become superconducting, these materials usually have to be taken to extremely low temperatures, varying between 1 and 20 K (or between -272 and -253 ° C), but in any case close to absolute zero.

However, since 1987, superconductivity has no longer been confined to these extreme temperatures and the researchers discovered that some copper oxide based materials were capable of achieving superconducting states at a temperature of 135 K (-138 ° C). Whereas conventional superconductors had to be cooled with liquid helium, these materials – known as high critical temperature superconductors – could be simply cooled with liquid nitrogen, making them far easier to use.

Abnormal electronic properties

To explain this phenomenon of superconductivity at high temperature, the physicists must elucidate the particular behavior of these materials which, before becoming superconducting, go through an intermediate "pseudogap" phase, during which abnormal electronic properties appear and which do not correspond to the behavior of conventional metals.

Several theoretical models were proposed to describe this phase. One of them, from Professor Varma of the University of California, Riverside, postulates the existence of a hidden order from which the superconducting state of the matter emerges: below a certain temperature, a new material state appears, in which microscopic loops of electric current form spontaneously. The pseudogap phase would be the result of the appearance of these current nano-loops.

This theory has just been validated by the research teams, through observations made with the IN20 polarized neutron spectrometer at the Laue Langevin Institute. Interpretation of this fascinating phenomenon appears to be close, but these observations have to be further validated on other compounds.

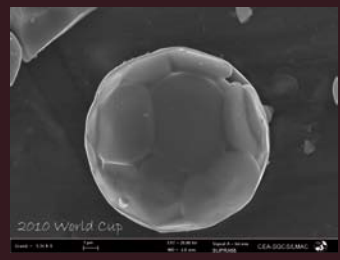
Press release – November 2010

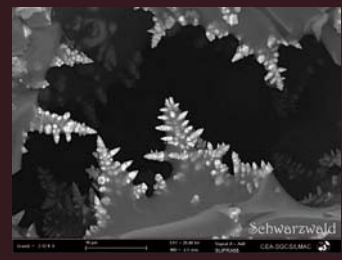
"Hidden magnetic excitation in the pseudogap phase of a model cuprate superconductor"
Yuan Li, V. Balédent, G. Yu, N. Barišic, K. Hradil, R.A. Mole, Y. Sidis, P. Steffens, X. Zhao, P. Bourges, M. Greven, Nature 468, 283-285 (10 November 2010)

THE SECRET LIVES OF NUCLEAR MATERIALS

Under the eye of the field-effect scanning electron microscope, nuclear materials reveal their secret side… The interactions between uranium and concrete look like magical Christmas trees; niobium carbide, a component in nuclear fuel cladding, looks like a football. These two photos, taken by the CEA fuel cycle technology department, won awards at the scientific photography competition at the 2010 Microscopy & Microanalysis Meeting in Portland (USA). This picture of sea urchins littering the sea floor is in fact rust that has formed on steel…

Les Défis du CEA n°155 – November 2010



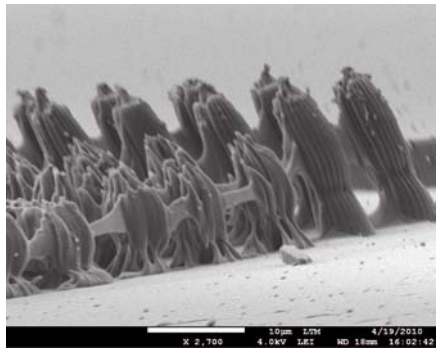


The Grand Prize
for best photo goes to Grenoble

The Biocollona team from the microelectronic technologies laboratory (LTM) has just won the Photo Grand Prize at the 36th International Conference on Micro and Nano Engineering in Genoa. This prize was for the best electron microscopy photograph from the nanotech community.

The international jury selected the LTM work from among seventy proposals from nanoscience experts. The work entitled "March of the Penguins" represents two-photon polymerization of a light-sensitive resin. This is the second time that the Grenoble team has won this international award.

In 2008, in Portland, the award went to "Beginning of life", resulting from work on the assembly and self-organization of colloids.



Marc Jary – Le Mensuel de Grenoble n°146 – December 2010

Biomanufacturing Symposium
reviews 30 years of production

More than 200 researchers and representatives from industry took part in the 3rd International Symposium on Biomanufacturing at Genopole®, and reviewed 30 years of production of hormones, enzymes, monoclonal antibodies, vaccines, and so on.

The first part of the symposium was devoted to presenting industrial biopharmaceutical achievements, new technological avenues and the latest generations of therapeutic biomolecules. This was followed by sessions on alternative expression systems (plants, micro-algae, etc.), on technological support for pharmaceutical biomanufacturing and on biosimilars.

The various approaches to and the latest advances in synthetic biology were presented by eighteen internationally acclaimed speakers during the "Synthetic Biology" international conference, attended by 180 participants.

www.genopole.fr/Home.html

VISIATOME
100,000th visitor

On October 18, 2010, as the curtain-raiser to the "Fête de la science" festival, the Visiatome welcomed its 100,000th visitor. This was an opportunity for Christian Bonnet, Director of CEA Marcoule, to present awards to two first-year classes from Frédéric Mistral high school in Avignon, which took part in the workshops proposed throughout the week. Visiatome was opened in April 2005 and receives an average of 20,000 visitors every year, broken down as follows: one third children visiting with their schools, one third French and foreign general public (adults, families, associations and so on) and one third professional visitors. In addition to the permanent exhibition covering 600 m², it proposes temporary exhibits, conferences for the general public and other special events throughout the year.

Marcoule et vous – December 2010

www-visiatome.cea.fr/

HANNOVER MESSE 2011 4 to 8 April

Under the banner of 'Smart Efficiency', the companies exhibiting at the 13 international flagship fairs during HANNOVER MESSE 2011 will be presenting key technologies used in industry around the world.

Exhibiting companies will be presenting intelligent solutions aimed at cutting costs, optimizing process efficiency and conserving resources at every stage of the production chain.

The special events, also embrace the core elements of 'Smart Efficiency' during lectures, congresses and forums, as well as seminars and workshops.

France will be the official Partner Country. Reflecting the keynote theme "Innovation for sustainable growth", the French exhibits will put the focus on the energy sector, sustainable mobility and energy efficiency.

Atomexpo 2011 - June 6-8 Moscow, Russia

ATOMEXPO 2011 is host to a specialized exhibition for nuclear enterprises and related industries.

For top managers and specialists, the international exhibition will provide a unique opportunity to see the products and services of one of the most promising industries in Russia.

The forum will also be home to the International Congress, another opportunity to get an idea of what the nuclear industry needs and what it is capable of and to discover new promising business contacts.

The 9th China International Exhibition on **Nuclear Power Industry** 2011

Ever since the first inception in 1995, the International Exhibition on Nuclear Power Industry has been gaining a tremendous and unanimous support from the Chinese governmental authorities, the world's organizations concerning nuclear power and the International Atomic Energy Agency (IAEA).

The year of 2011 marks 17 years' existence for this event. Throughout these years, a considerable number of the most influential enterprises have exhibited their novel technologies and solutions. The event serves to encourage business communication and interaction by means of coherent international cooperation and conferences focusing on state-of-the-art technologies and analysis of global trends. Fuelled by continuous rapid development of the nuclear industry, advances in size and scope of exhibits can be observed.

Nicolas Sarkozy visits the **Megajoule Laser**

French President Nicolas Sarkozy, accompanied by the Minister for Higher Education and Research, Valérie Pécresse, visited the Megajoule Laser (LMJ) on the CEA/Cesta site on October 14th 2010.

He was welcomed to the site by the CEA Chairman, Bernard Bigot, the Director of military applications, Daniel Verwaerde, the Deputy Director of military applications, Dominique Monvoisin, and the Director of the Site, Jean-Pierre Giannini. After a brief presentation of the Simulation program, the French leader officially opened the building and visited the laser hall in which the Petawatt beam (see PETAL box) is to be installed, and then the hall where physics experiments will be conducted as of 2014. He talked about the potential of the LMJ for research, innovation and economic development. He considered that the science program involved is of considerable value for France and will enable it to guarantee the future of its deterrent force for as long as necessary, thus consolidating French leadership in the field of very high energy laser research.

To find out more, read the speech (in French) by Nicolas Sarkozy on the government's Elysée website www.elysee.fr/

The PETAL will be build in the LMJ

The PETAL (PETawatt Aquitaine Laser) project was launched in 2003 by the Aquitaine Region, together with the Ministry responsible for Research and the European Union. It consists in building a multi-petawatt (ultra-short pulses of a few picoseconds) laser chain, coupled with a high-energy laser (long pulses of a few nanoseconds).

The considerable potential of the LMJ, allied with the synergy between the projects of the two installations, led to the proposal that PETAL be built in the LMJ. The creation of this very large experimental physics facility will serve research into inertial confinement fusion, the study of matter in extreme conditions, and particle acceleration. It will enable French and foreign scientists to explore new ways of producing clean energy, of recreating in the laboratory physical conditions which can, for example, only be found in stars, and to test various medical applications for the physics of laser-matter interaction.

The scientific brochure collection

CEA's topical brochures: these illustrated brochures, destined for the general public, aim to provide an initial approach to scientific notions. The collection in English, currently in paper format, is completed with four titles:

8. Microelectronics

14. Radioactive waste

16. Numerical simulation

18. The nanoworld

This collection will shortly be available online.

A new Clefs CEA

The scientific and technical review, Clefs CEA reports on important subjects in research and development studied by the CEA. The articles, written in part by scientists, address the public with a general scientific culture.

Clefs CEA N°58, autumn 2009 "Unraveling the secrets of the Universe".

An English version is available on line and on CD-Rom.

www.cea.fr

HUMAN RESOURCES

THE LIST OF THE INTERNATIONAL COURSES SCHEDULED FOR 2011

Organized by the National Institute for Nuclear Science and technology (INSTN) & the European Nuclear Education Network Association (ENEN) at CEA Saclay, France.

INTERNATIONAL COURSES	FROM	TO	REGISTRATION DEADLINE
Principles and operation of nuclear reactors	14/03/2011	25/03/2011	28/02/2011
Criticality – Safety (new)	28/03/2011	08/04/2011	09/03/2011
Operation and safety of pressurized water reactors (new)	16/05/2011	27/05/2011	22/04/2011
Nuclear materials for PWR (new)	06/06/2011	10/06/2011	16/05/2011
Thermal hydraulics of light water reactors - Basic	14/06/2011	24/06/2011	30/05/2011
Thermal hydraulics of light water reactors – Advanced course	20/06/2011	24/06/2011	30/05/2011
Neutronics for light water reactors	27/06/2011	08/07/2011	06/06/2011
Generation IV Nuclear reactor systems for the future	19/09/2011	23/09/2011	26/08/2011
Nuclear fuel cycle	10/10/2011	21/10/2011	05/09/2011
Nuclear waste management	Upon request		
Dismantling experience of nuclear facilities	Upon request		

Don't hesitate to contact nadia.nowacki@cea.fr if you need any further information about the courses: contents, fees and so on.

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